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Online information systems with alien species occurrence records in Europe

Coverage, complementarity and compatibility

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Abstract

This report assesses the coverage of thirty existing on-line national, regional and global databases from which alien species occurrence records within the territory of the European Union can be retrieved. In addition, it quantifies their degree of complementarity, and as such the added value of an integrated information system. Finally, it includes a qualitative evaluation of the feasibility of combining alien species information from existing databases at EU level.

Our comparative analysis of occurrence data across 30 online databases with alien species records uncovers a high degree of complementarity of information. The most comprehensive resource for country level alien species occurrences in Europe (DAISIE) fails to report about one out of every four species known to be alien to one or more countries within the EU27 + Norway territory. When accessing only a single database, a minimum of 10,000 species by country records stay unaccounted for at European level.

The distributed and largely independent nature of existing alien species information systems has multiple consequences: (i) In the absence of an overarching data exploration system, it complicates the retrieval of information, and the identification of knowledge gaps; (ii) It allows systems to diverge and as such become less compatible; (iii) It potentially makes inefficient use of existing financial and intellectual resources.

The efficiency and accuracy of existing databases could be improved if communication between systems was enhanced. Expert knowledge could be shared and harmonization of the information would facilitate the retrieval of information, for example through a common network of interoperable web services. Integrated alien species databases currently report occurrences at country level, with limited value for scientists and managers. A shift towards georeferenced occurrences could be achieved in a cost-effective way by link linking to biodiversity databases and digitized archives of relevant journals.

Introduction and aims

In the past decade, research and policy needs have triggered the collection and dissemination of information on alien species. This information can be retrieved from a variety of resources, such as online databases, peer-reviewed and grey literature, unpublished project or institutional datasets, and taxonomic experts. The accessibility of this information can be increased by collating it in integrated online databases. These databases enable researchers to deepen their understanding of the process and impact of alien species introductions. This knowledge is being fed into policies, whose successful implementation also depends on the quality and availability of the alien species records.

Several EU Member States have formalized their policy in an invasive species strategy. A key component of these strategies is often the establishment and maintenance of a national alien species database. On the European level, the need for an European strategy on invasive species and an effective early warning system have been expressed at the highest political level (e.g. the Environmental Council and the European Parliament. In response, the Commission has outlined four policy options in its communication 'Towards an EU Strategy on Invasive Species' (COM(2008) 789 final). All options other than the business as usual approach require up to date knowledge about the distributions of aliens in the territory. The efforts to be dedicated to this task vary across the options from updating existing alien species databases to the set-up and maintenance of a pan-European alien species information centre. In response to this communication, the European Council highlighted 'the fact that the Strategy should provide for the establishment and maintenance of a comprehensive inventory of IAS' (Environmental Council conclusions of 25 June 2009, 11412/09). Furthermore, it is the opinion of the European Economic and Social Committee that 'the best way to tackle the threat of invasive species would be through the adoption of a comprehensive, dedicated EU legal instrument as well as the establishment of a new European Agency to coordinate and execute the management of invasive species' (The European Economic and Social Committee' opinion 11June 2009, NAT/433 Invasive species). The Committee does not specify the role of such agency in the collection of information on alien species. Overall, the policy bodies of the European Union recommend building on existing initiatives, while recognizing the need for maintenance and better harmonization. These recommendations are backed up by European citizens and stakeholders. In a public survey issued by the Commission, the majority of respondents (89% of 881) considered it important or very important that such a system provides consistent information and early warning throughout the EU (http://ec.europa.eu/environment/nature/invasivealien/docs/results_consult.pdf). The respondents also found it at least important that such information is made accessible to the public (88%). When stakeholders were asked for their views on the EU strategy on invasive alien species in September 2010, they stressed the importance of early warning and rapid response, and the crucial role of updated databases in this context (Stakeholder consultation minutes on http://circa.europa.eu/Public/irc/env/ias/library?l=/general_information/stakeholder_03092010&vm=detailed&sb=Title).

In recent years there have been a number of initiatives to integrate country specific information into national, regional or even global databases. Based on a questionnaire issued by the EC Joint Research Centre in spring 2009, most EU Member States have alien species lists, (Vandekerkhove & Cardoso, 2010). The respondents provided links to 23 online (sub)national databases containing occurrence records of alien species, and indicated that the creation of on-line databases is for some Member States or organism groups a work in progress.

At the European level, the 6th Framework Programme project DAISIE (Delivering Alien Invasive Species Inventories for Europe) has been the most comprehensive endeavour to bring together information on alien species. At present, it encompasses 63 countries or regions in the European wider region. After the termination of the project in 2008, the portal remained active but maintenance occurs

ad hoc and is restricted to few organism groups. In parallel, the NOBANIS consortium (North European and Baltic Network on Invasive Alien Species) provides a gateway to regularly updated information on alien species in 20 Northern and Central European countries. NOBANIS and DAISIE cover marine, freshwater and terrestrial alien species. Other initiatives focused on a single type of ecosystem or organism group. The Baltic Sea Alien Species Database provides a detailed account of alien species in the Baltic Sea, while the Mediterranean Science Commission (CIESM) has produced atlases for alien species belonging to key organism groups, now covering fish, macrophytes, crustacean decapods and molluscs.

Part of the information is also feeding global initiatives such as GISD. Alien fish and bird records have been collated at the global scale, respectively via FishBase and Avibase. The Plant Quarantine Data Retrieval System of the European and Mediterranean Plant Protection Organization provides detailed information on the global distribution of host plants of quarantine pests, and includes many non-native species. Movements of species across countries are recorded by the Database on Introductions of Aquatic Species (DIAS) of the Food and Agriculture Organization of the United Nations (FAO). DIAS currently documents over 5500 translocations with a historical focus on freshwater fish but now also including some molluscs, crustaceans, and marine species. The Invasive Species Specialist Group (ISSG) of the IUCN-World Conservation Union has produced the Global Invasive Species Database (GISD). GISD is the most advanced attempt to combine the information from existing databases with expert knowledge at a global scale. The information collected by GISD and other initiatives are gradually being fed into the Global Invasive Species Information Network. For now, GISIN relies for most European countries largely on information collected within DAISIE which is supplemented with information from GISD. Most recently, the Centre for Agricultural Bioscience International (CABI), released a beta version of their Invasive Species Compendium. The compendium has a global coverage with active involvement of over 70 countries. The beta version contains data sheets on over 1500 invasive species and animal diseases. For each species detailed information will become available on its biology, ecology, impacts and management, as well as an interactive distribution map. Furthermore, the compendium contains a species reporting module, a glossary and a library with currently 776 full text articles and over 65026 abstracts. Most of the information is currently password protected.

This report assesses the coverage of thirty existing on-line national, regional and global databases from which alien species occurrence records within the territory of the European Union can be retrieved. In addition, it quantifies their degree of complementarity, and as such the added value of an integrated information system. Finally, it includes a qualitative evaluation of the feasibility of combining alien species information from existing databases at EU level.

Methodology

Online databases containing occurrence records for alien species were identified through a questionnaire issued by the Joint Research Centre and directed to EU national experts on alien species (Vandekerkhove & Cardoso, 2010). Others were found through a web search. Only databases that provided free access to EU Member State (+ Norway) specific species occurrences were considered. Some databases distinguish between the mainland and associated islands (e.g. Denmark vs. Greenland and Faroer Islands, Portugal vs. Azores and Madeira, Spain vs. Canary Islands, Norway vs. Svalbard), while others only provide country specific records without specifying the territory. To ensure comparability across databases, species records were aggregated at country level, including also species records for geographically remote islands.

Alien species occurrence records were extracted from thirty online databases in January and February 2010 (Table 1; more detailed descriptions in Annex 1). Five databases have a global dimension (GISD, DIAS, EPPO, FishBase and Avibase), four databases have a European (DAISIE) or regional dimension (NOBANIS, CIESM, Baltic Sea Alien Species Database), and the majority are national or

subnational databases (15 countries: Austria, Belgium, Germany, Denmark, Estonia, Greece, Spain, Republic of Ireland, Lithuania, Luxemburg, Poland, Portugal, Norway, Sweden and the United Kingdom). All databases, except the Baltic Sea Alien Species Database, allowed extraction of country level species occurrences. In the Baltic Sea Alien Species Database occurrences are organized in sea basins, and we assumed that alien present in a basin occur in all countries to which the basin belongs (Table 2).

Table 1: List of databases from which alien species occurrence data were extracted. National and subnational databases were coded using the official EU Member State coding (AT: Austria, BE: Belgium, DE: Germany, DK: Denmark, EE: Estonia, EL: Greece, ES: Spain, IE: Republic of Ireland, LT: Lithuania, LU: Luxemburg, PO: Poland, PT: Portugal, NO: Norway, SE: Sweden, UK: United Kingdom). The code suffix indicates the regions (N: Northern Ireland, E: England) or that the database is restricted to a particular organism group (plants) or water category (MAR: marine waters; AQ: freshwater + marine waters). If no citation or copyright is provided by the database website, the URL of the site is given. All web links can be found in Annex 1.

Code	Database	Reference / copyright / URL
AT	OASIS 2.0 (Austrian Biodiversity Information System)	Kiss et al., 2007
Avibase	Bird Checklists of the World	© 2010 Denis Lepage
Baltic Sea	Baltic Sea Alien Species Database	Baltic Sea Alien Species Database, 2007
BE	Harmonia (Invasive Species in Belgium)	Harmonia database, 2010
BE-MAR	Checklist for Aquatic Alien Species in the Belgian Part of the North Sea and Adjacent Estuaries	VLIZ, 2007
CIESM	Atlas of Exotic Species in the Mediterranean	© 2005 CIESM
DAISIE	Delivering Alien Invasive Species Inventories for Europe	European Invasive Alien Species Gateway, 2008
DE-AQ	Aquatic alien species in German Inland and Coastal Waters	© 2005 Stefan Nehring
DE-PLANTS	FloraWeb	www.floraweb.de
DIAS	Database on Introductions of Aquatic Species	© 2010 FAO
DK	Danish Database of Introduced Species	www.skovognatur.dk
EE	Estonian Alien Species Database	loodus.keskkonnainfo.ee
EL-MAR	Ellenic Network on Aquatic Invasive Species (ELNAIS)	© 2010 Ellenic Network on Aquatic Invasive Species
ES	Invasive Exotic Species of the Iberian Peninsula (InvasIber)	invasiber.org
FishBase	A Global Information System on Fishes	Froese & Pauly, 2010
GISD	Global Invasive Species Database	Global Invasive Species Database, 2005
IE	National Invasive Species Database	www.biodiversityireland.ie
IE-PLANTS	Database of Alien Plants in Ireland	© Trinity College Dublin
LT	Lithuanian Invasive Species Database	www.ku.lt/lisd
LU-PLANTS	Neophyten in Luxemburg	© 2006-2010 Section écologie M.N.H.N.L. – Luxembourg
NO	Norwegian Alien Species Database	www.artsdatabanken.no
NOBANIS	North European and Baltic Network on Invasive Alien Species	www.nobanis.org
PO	Alien Species in Poland	© 2009 Institute of Nature Conservation, Polish Academy of Sciences

PQR	Plant Quarantine Data Retrieval System	www.eppo.org
PT-PLANTS	Invasive Plants Species in Portugal	www1.ci.uc.pt/invasoras
SE-MAR	Alien species in Swedish seas and coastal areas	www.frammandearter.se
UK	Non-Native Species Information Portal	© 2009 GB Non-native species secretariat
UK(E)	Audit of Non-Native Species in England	Hill et al., 2005
UK(N)	Invasive Alien Species in Northern Ireland	© 2006 National Museums Northern Ireland
UK-MAR	Non-Native Marine Species in British Waters: a Review and Directory	Eno et al., 1997

Table 2: Baltic Sea basins and their allocation to countries.

Sea basin	Denmark	Estonia	Finland	Germany	Latvia	Lithuania	Poland	Sweden
Baltic Proper		X	X		X	X	X	X
Curonian Lagoon						X		
Gulf of Bothnia			X					X
Gulf of Finland		X	X					
Gulf of Riga		X			X			
Kattegat/Belt Sea	X			X				X
Oder Lagoon				X			X	
Vistula Lagoon							X	

From most databases, all records for the EU-27 Member States and Norway were extracted, except in the following cases:

- Some databases are not targeting alien or invasive species, but serve a more general purpose. These usually are biodiversity databases, such as FishBase or Avibase. The Austrian database was designed to support legal protection of species, and focuses on endangered species. From these databases, only the introduced species were extracted. It should be stressed however that these databases do not aim to provide a full coverage of the alien species present in the country, and therefore should not be evaluated upon their completeness. Here, we only use the alien species records extracted from these databases to complete and validate our picture of alien species in Europe.
- All records of alien, invasive and cryptogenic species that were observed at least once in the Member State were extracted. Species listed as invasive or cryptogenic were added, as a preliminary analysis showed that they matched with records from alien species databases.
- Species listed as extinct, as well as casual alien species were included. Species listed as potential aliens (watch lists), and reintroduced and naturalized aliens were excluded (pre-1500 if specified).
- The EPPO database contains pests and invasive alien plants. We included only pests with at least some reported records (X1-X3 pests: few records, limited distribution or widespread), and excluded pests whose occurrence in a given country was unclear (X0 pests: no details on the distribution available). We further excluded pests (mainly viruses) that are not listed as alien in any database (329 of 571 pests deleted), because for these it is not clear if they are native or alien to Europe. All invasive and potentially invasive alien plants were included.
- From the alien species database of England (UK(E)), ‘aliens’ categorized as ‘formerly native’, ‘native with large addition from domestic or non-native stock’ and ‘native or alien, probably or possibly introduced’ were excluded. The extraction was limited to species that are ‘spontaneous hybrids between native and introduced taxa’ and ‘introduced (not present as native in post-glacial period; this includes taxa that have spread naturally to Britain from introduced populations in Europe)’, ‘new species derived from a spontaneous hybrid’, and ‘newly arrived (taxa with an unknown history that appear to have arrived since 1950 and from their subsequent behavior seem likely to be introductions)’.

Prior to the merging of the extracted records, species names were revised in a semi-automated way. First, 'species' names were reduced to their essence (i.e. genus, species and infraspecies/hybrid name). Using the text-to-columns function in Excel, names of describing authors and the year of species descriptions could easily be removed. Likewise, special characters were removed, and infraspecies and hybrid notations were standardised (e.g. var. for variant, and subsp. for subspecies). Redundant spaces were removed using the Excel trim function.

After extraction of the data, the species, subspecies and hybrid records were combined into a single database, using another Excel add-in (Merge Tables Wizard V2.0, AbleBits, Homel). The integrated data file contained for each alien the database specific presence or absence in each of the 27 EU Member States and Norway. Aliens were assigned to families, orders, classes, phyla and kingdoms following the taxonomy of Encyclopedia of Life (EoL; http://www.eol.org/). For species not listed in EoL, the taxonomy of the Global Biodiversity Information Facility (GBIF; http://www.gbif.org/) or the source database was followed. Species were identified as terrestrial, freshwater, marine or a combination of this, based on their dependence on freshwater or marine water during at least part of their life cycle. This information was largely retrieved from the source databases.

The integrated data file formed the basis for the analysis of the coverage, complementarity and compatibility of the source databases. The coverage of databases across European countries is visualized using the software MapWindow GIS version 4.8.1 (© 2004-2009 MapWindow Open Source Team; www.mapwindow.org). The complementarity of up to three (groups of) databases is visualized with Venn diagrams (http://www.venndiagram.tk/). Database compatibility is analyzed in a qualitative and quantitative way. For the qualitative comparison, a factsheet with a standardized list of database descriptors is compiled for each database (Annex 1). This facilitates the identification of a number of incompatibilities across databases (e.g. language, resolution, geographical and taxonomic coverage, etc.). Two sources of incompatibilities that are most relevant for the merger of country level occurrence records are addressed in more detail: differences in defining alien species and variations in species names. The importance of the latter is assessed in a quantitative way by comparing records in databases using the 'original species names' with those in databases where these names have been revised. 'Original species names' are the names as they are extracted from the databases, after trimming of redundant spaces, removal of author notations and special characters, and standardisation of infraspecies notations (e.g. subsp., var., hyb., etc).
The revision included three steps:

(1) *Spelling errors:* Species names that differed from other species names in up to three characters were identified in automated way, using an Excel add-in (Fuzzy Duplicate Finder V3.0; AbleBits, Homel). Species names that were similar to each other were checked one by one to verify if it was a fuzzy duplicate (spelling error) or a different species, and records were merged if needed.

(2) *Synonyms:* Synonyms for marine species names were retrieved using a taxon matching tool provided by the World Register of Marine Species (WoRMS; http://www.marinespecies.org/aphia.php?p=match). A more comprehensive taxon matching tool is being developed by the Global Names Architecture (GNA; http://www.globalnames.org/), and will cover not only marine but also terrestrial and freshwater ecosystems. A small number of synonyms were detected and revised through ad-hoc checking of a subset of original species names (mainly using the portal of the Global Biodiversity Information Facility; GBIF)

(3) *Infraspecies*: In addition, original species names were checked in Catalogue of Life, 2009 (CoL2009), and in case the 'infraspecies' was not listed in CoL2009 but the 'species' was, then 'infraspecies were lumped to species level.

Scatterplots and bar charts were drawn with Sigmaplot 6.0 (Systat Software Inc., 2005) and statistical analyses were performed with Statistica 9.0 (Statsoft Inc., 2009).

Results

1. Coverage

The databases cover all 27 EU Member States and Norway. In general, fewer aliens are reported from Eastern and Southern European countries (Fig. 1). Within Western Europe, numbers of aliens vary from 199 (Luxembourg) and 869 (The Netherlands) to almost 4000 (United Kingdom: 3814).

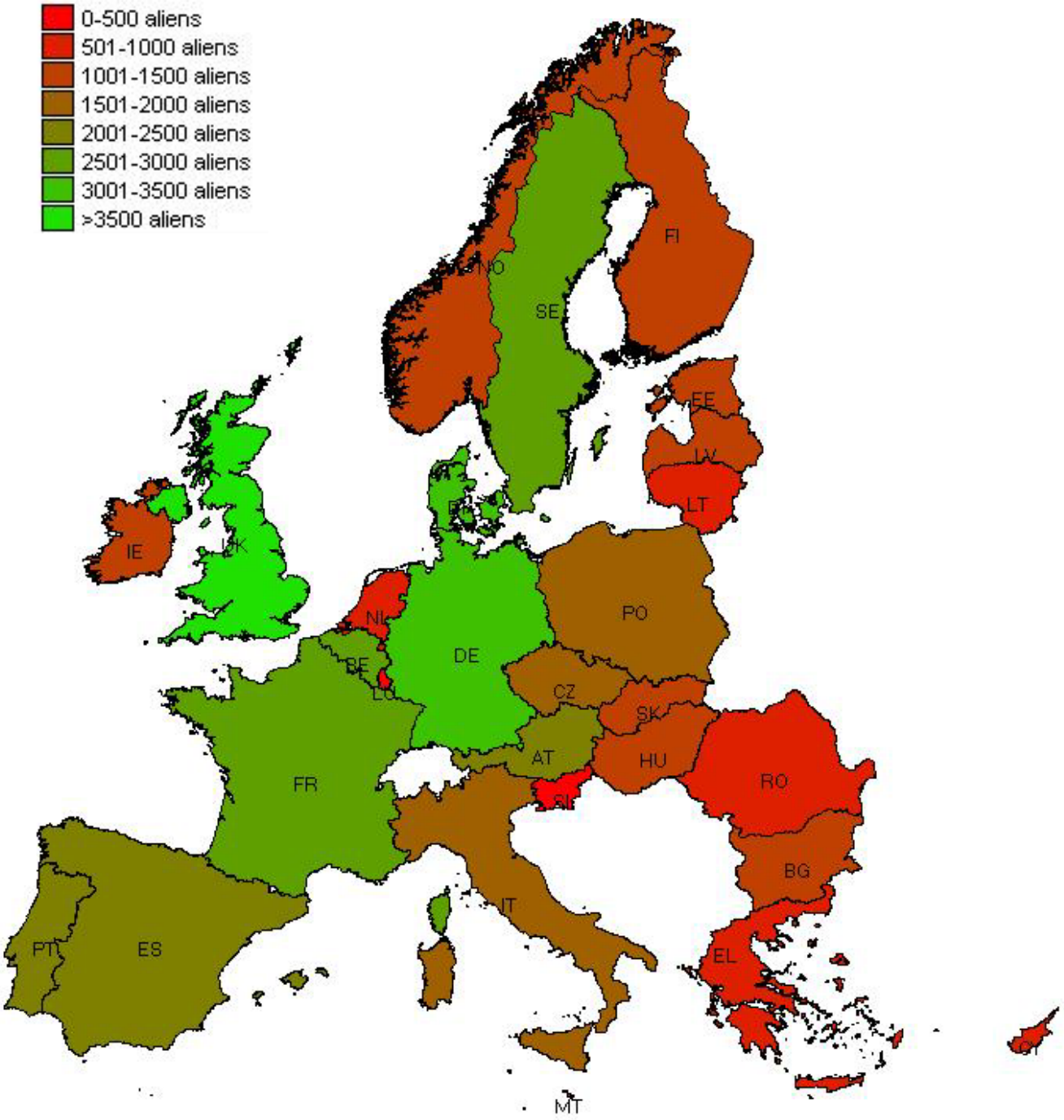


Figure 1: Map showing for which of the 27 EU Member States and Norway databases with alien species occurrences are available and accessible online. The colour coding reflects the number of alien species that are listed by the national databases.

Five of the thirty databases contain data for all 27 EU Member States: DAISIE, DIAS, FishBase, GISD and PQR (Fig. 2, Table 3). Only the European database DAISIE ('Delivering Alien Species Inventories for Europe') covers all organism groups and environments. The Global Invasive Species Database (GISD) is limited to invasive aliens, which constitute only about 1.4% of all alien species based on the ratio of GISD records over the records in the combination of 30 databases. The Database on Introductions of Aquatic Species (DIAS) of the United Nations Food and Agriculture Organisation lists 355 alien species in the EU-27 + Norway area, suggesting either an incomplete coverage of DIAS or a predominance of terrestrial aliens. The Plant Quarantine Retrieval Database of the European and Mediterranean Plant Protection Organization as well as FishBase and Avibase are limited to certain organism groups, respectively pests and invasive plants, fish and birds. The biodiversity database Avibase has a global coverage, but contains no alien species records for three European Member States (Cyprus, Estonia and Malta).

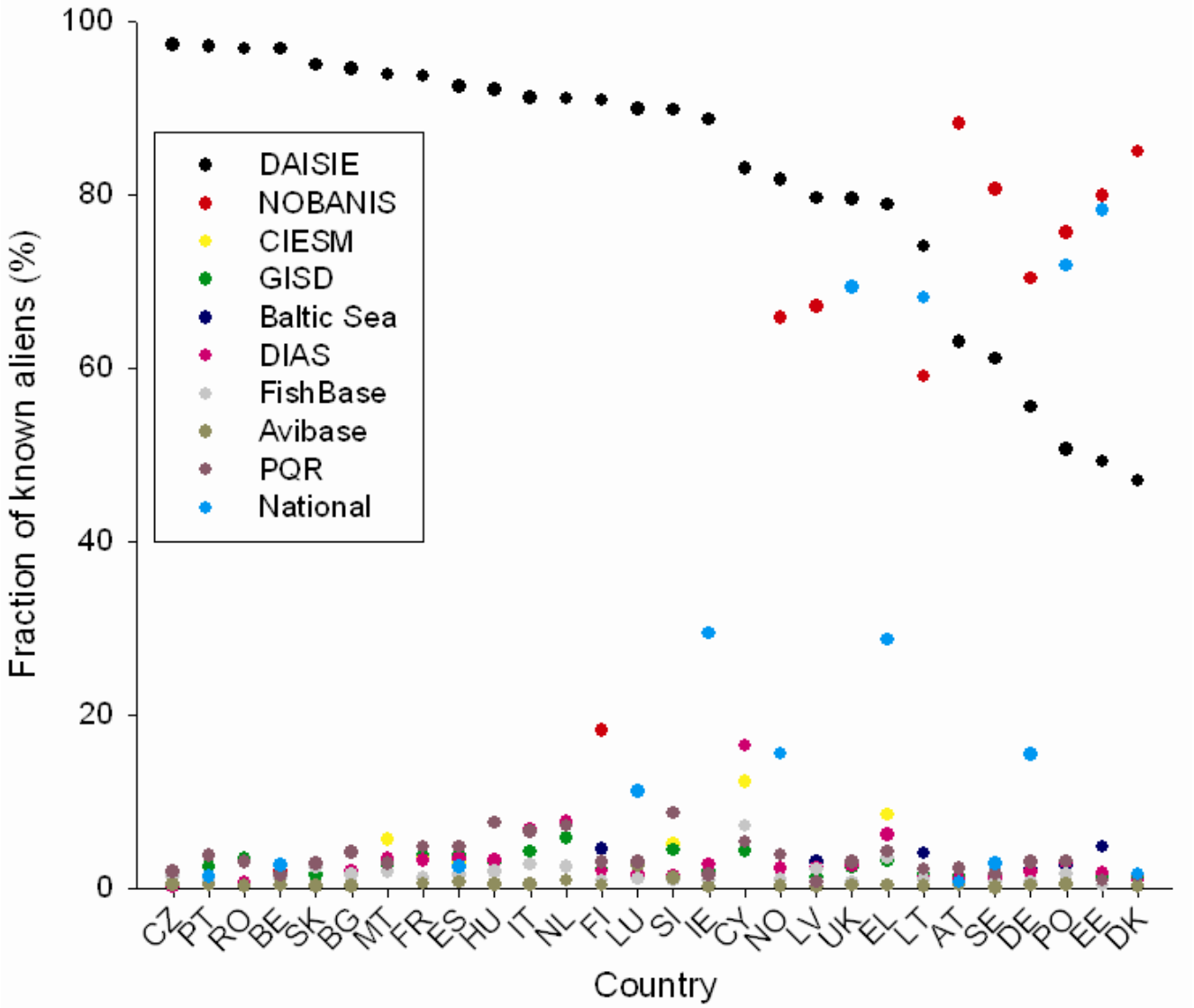


Figure 2: Percentage of known alien species that are listed by the databases for each of the 27 EU Member States and Norway. Country codes: AT: Austria, BE: Belgium, BG: Bulgaria, CY: Cyprus, CZ: Czech Republic, DE: Germany, DK: Denmark, EE: Estonia, EL: Greece, ES: Spain, FI: Finland, FR: France, HU: Hungary, IE: Republic of Ireland, IT: Italy, LT: Lithuania, LU: Luxemburg, LV: Latvia, MT: Malta, NL: The Netherlands, NO: Norway, PO: Poland, PT: Portugal, RO: Romania, SE: Sweden, SI: Slovenia, SK: Slovakia, UK: United Kingdom). The databases are described in Annex 1 (NOB = NOBANIS, BALT = Baltic Sea Alien Species Database, FISH = FishBase, AVI = Avibase, NAT = national database with highest number of alien species records for the country).

NOBANIS, CIESM and The Baltic Sea Alien Species Database are international databases that focus on a particular area within Europe. The North European and Baltic Network on Invasive Alien Species (NOBANIS) covers less than half of the EU-27 countries. It lists about two thirds of the number of species that DAISIE lists, and about one third of the species by country records in DAISIE. The atlases compiled by the Mediterranean Science Commission (CIESM) and the Baltic Sea Alien Species Database are restricted to marine organisms, and cover respectively seven and eight EU-27 Member States. The four CIESM atlases each focus on a particular group of marine organisms (fish, crustacean decapods ad stomatopods, molluscs and macrophytes), and together detail distributions of 246 aliens. The Baltic Sea Alien Species Database is more inclusive in terms of organism groups, but lists only 113 alien species.

Table 3: List of databases with alien species occurrence records and their coverage of the 27 EU Member States (#MS; +1 if also Norway is covered). The table shows for each database the number of alien species ('Aliens') listed by each database in the EU27+Norway, and the sum over all countries of the species records per country ('species x country records').

Database code	EU-27	Aliens	Species x country records	Organisms / environments
DAISIE	27+1	9843	35172	All
NOBANIS	12+1	6876	13702	All
UK(E)	1	2644	2644	All
PQR	27+1	323	1392	Plants / Pests
DIAS	27+1	355	1071	Aquatic species
GISD	27+1	189	1021	All
PO	1	1007	1007	All
EE	1	920	920	All
LT	1	669	669	All
FishBase	27+1	154	540	Fish
DE-PLANTS	1	494	494	Plants
CIESM	7	246	431	Marine species
Baltic Sea	8	113	421	Marine species
IE-PLANTS	1	408	408	Plants
EL-MAR	1	275	275	Marine species
NO	1	203	203	All
UK	1	147	147	All
Avibase	25	39	145	Birds
DE-AQ	1	131	131	Aquatic species
IE	1	83	83	All
SE-MAR	1	72	72	Marine species
UK-MAR	1	69	69	Marine species
BE	1	68	68	All
BE-MAR	1	65	65	Marine species
DK	1	54	54	All
ES	1	49	49	All
UK(N)	1	49	49	All
PT-PLANTS	1	32	32	Plants
LU-PLANTS	1	22	22	Plants
AT	1	16	16	All

Online national (or subnational) databases are available for 15 EU Member States (see Fig. 3). Together, they provide information for 4758 species, or about half of the species known to be alien in one or more of the EU Member States. Several of these databases provide for a selection of alien species detailed distribution maps. For this report this information was lumped to presence-absence data at country level. This simplification facilitated the comparison with country level data provided by European and global databases. Combined, the national databases yield 7477 alien species x country records. This is only about 20% of the number of species x country records in DAISIE (limited to EU-27 + Norway), and about half of the species x country records in NOBANIS (12 EU Member States + Norway). The three most comprehensive national databases ('Audit of Non-Native Species in England', 'Alien Species in Poland' and 'Estonian Alien Species Database') account for 61% of the species x country records found in all 21 national databases. This suggests a large variation in coverage among national databases. Indeed, the number of species covered by the national databases ranges from 16 ('Neophyten in Luxemburg') to 2644 ('Audit of Non-Native Species in England'). Part of the variation is due to exclusive character of some databases, and to differences in the size of the territory. Five national databases are restricted to a particular group of organisms (i.c. plants: Germany, Ireland, Luxembourg and Portugal) and five are limited to a certain environment (aquatic: Germany; marine: Belgium, Greece, Sweden and UK). Within the UK, there are separate databases for England and Northern Ireland, and an additional database targeting only marine species, all this in addition to an all-inclusive UK-database. Variations in the taxonomical, environmental and geographical scope of the databases are important, but cannot fully explain why for example in the English database 2644 aliens are listed, while the Spanish database only lists 49 alien species.

Table 4: Product-moment correlation coefficients and significance levels of species numbers across databases. Full database names and descriptions can be found in Annex 1 (ALL = Combination of 30 databases; NOB = NOBANIS, BALT = Baltic Sea Alien Species Database, FISH = FishBase, AVI = Avibase, NAT = combination of online national databases, taking for each country the most comprehensive national/subnational database, WORST = Number of worst invasive alien species per country as determined by the 2006 Expert Group on Trends in Invasive Alien Species for report EEA/SEBI2010).

Database	ALL	DAISIE	NOB	CIESM	GISD	DIAS	FISH	AVI	PQR	BALT	NAT
DAISIE	0.89***										
NOB	0.72**	0.15									
CIESM	0.69	0.66	-								
GISD	0.71***	0.77***	0.52	0.71							
DIAS	0.37	0.43*	0.14	0.94**	0.77***						
FISH	0.22	0.38*	-0.02	0.93**	0.56**	0.76***					
AVI	0.70***	0.76***	0.41	0.46	0.84**	0.47**	0.34				
PQR	0.63***	0.72***	0.54	0.77*	0.93**	0.73***	0.55**	0.79***			
BALT	0.64	0.73*	0.51	-	0.43	0.34	-0.15	0.25	0.55		
NAT	0.30	0.29	-0.31	-	0.44	-0.64	0.60*	0.07	0.18	0.34	
WORST	0.53**	0.37	0.45	0.77*	0.51**	0.48**	0.26*	0.22	0.46*	0.01	0.51

*: P<0.05, **: P<0.01; ***: P<0.001

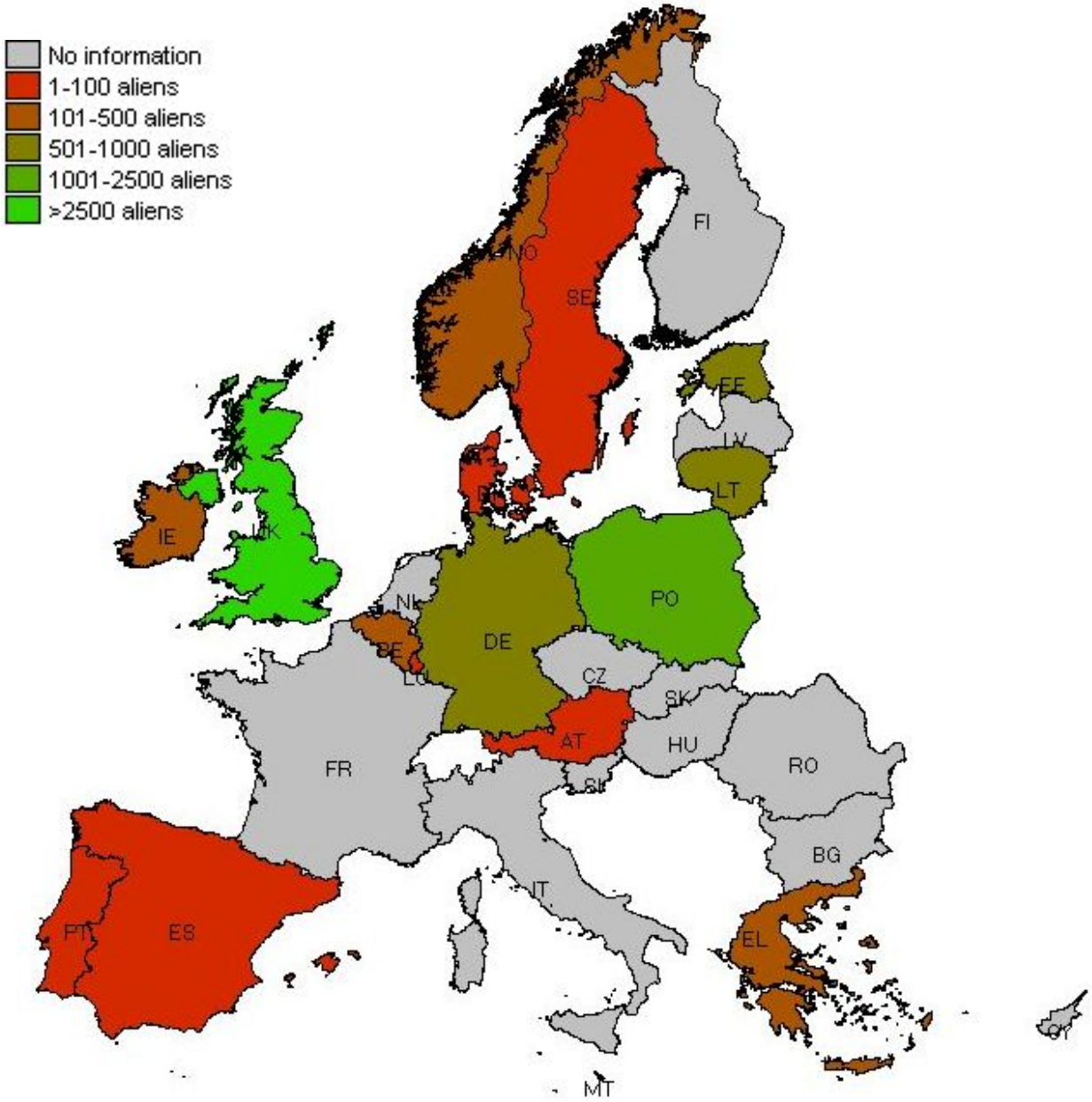


Figure 3: Map showing for which of the 27 EU Member States and Norway national alien species databases are available and accessible online. The colour coding reflects the number of alien species that is listed after combining records from thirty databases. Country codes as in Figure 2.

The variations in total number of aliens found among countries reflected well the variation observed in several individual databases (Table 4). These include not just DAISIE and NOBANIS, the databases that contribute the most to the total number of aliens, but also databases that contain only a small fraction of the total number of European (GISD: 1.4%, Fig. 4b; Avibase: 0.3%, Fig 4b; PQR: 2.3%). Although the list of introduced birds in Avibase is four times shorter than that of introduced fish in FishBase, the latter do not correlate with total numbers of aliens (Table 4). The total number of aliens per country is not determined by variations in the size of national databases. An expert group on Trends in Invasive Alien Species identified in 2006 163 aliens as 'worst invasive alien species' (EEA/SEBI2010). Although these cover only 1.2% of the aliens known in Europe, their numbers correlate well with that of the total numbers of aliens per country.

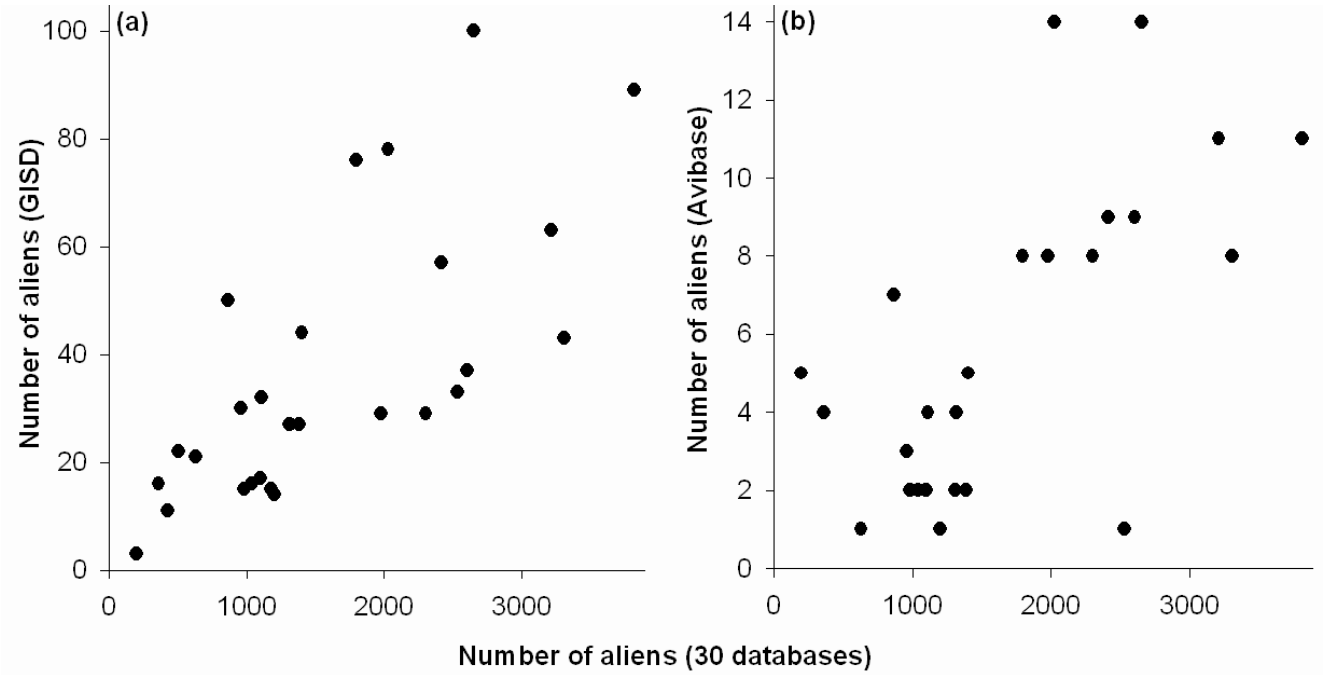


Figure 4: Scatterplot of the total number of alien species per country after combination of the alien species records from thirty databases versus the number of aliens per country listed in (a) GISD and (b) Avibase.

2. Complementarity

For each country, data were extracted from six to ten databases (on average 7.6 databases). Of all 13827 alien species names recorded within one or more of the 27 EU Member States and Norway, 71% are listed in DAISIE for that territory (Fig. 5a). NOBANIS covers half of the known alien species, and the other 28 databases together cover about one third of these species. NOBANIS covers only a subset of the EU Member States, while DAISIE encompasses all EU27 countries and Norway. Still, only 57% of the species names listed in NOBANIS can be found in DAISIE. The other, mainly national databases, add almost 1000 alien species names to the ones listed by DAISIE and/or NOBANIS. Only 15% of the alien species names are found in DAISIE and NOBANIS and at least one of the 28 other databases.

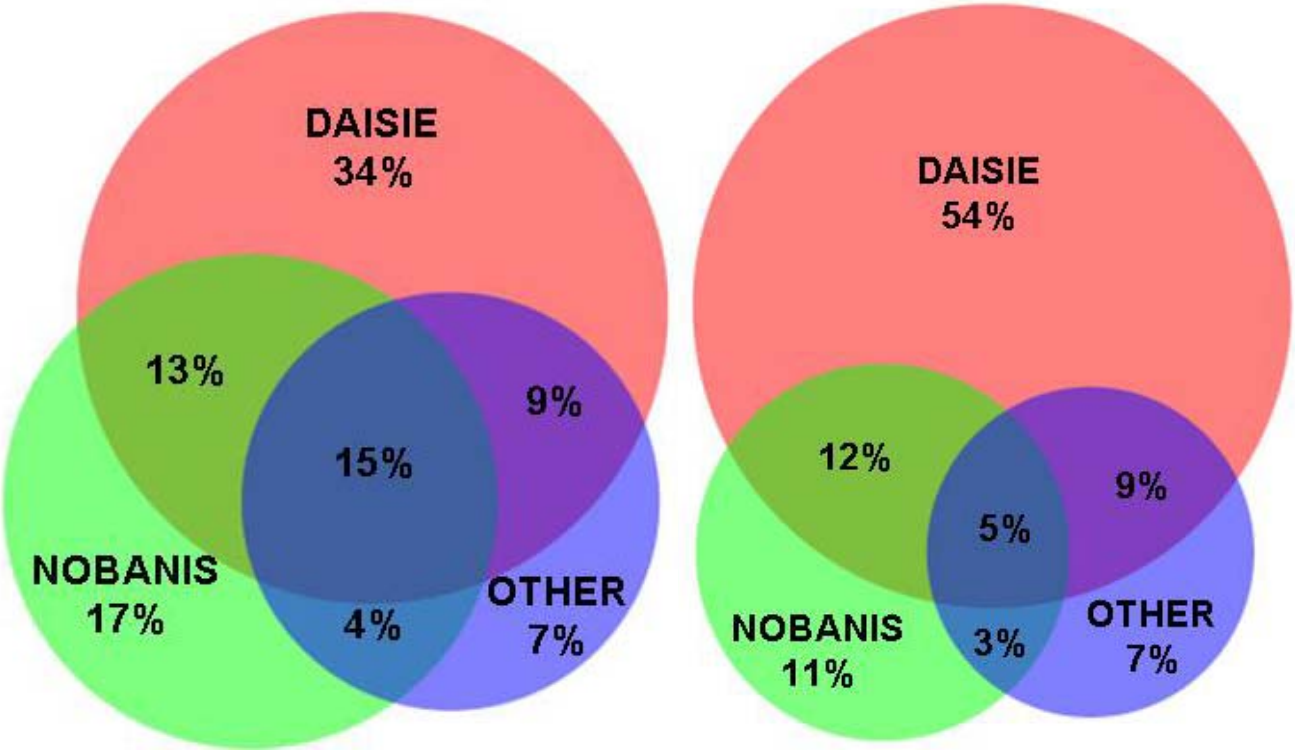
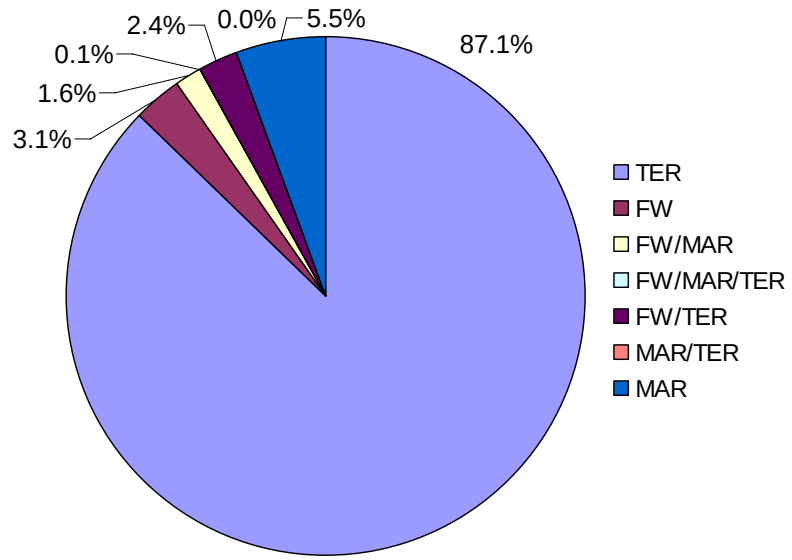


Figure 5: Venn diagrams showing the complementarity in (a) species records and (b) species x country records among the databases DAISIE, NOBANIS and the combination of 28 other databases for the EU27 + Norway.

The highest number of species by country records is found in DAISIE (35172 records; Fig. 5b). Only one third (32%) of these records can be found in NOBANIS or one of the other databases. On the other hand, NOBANIS and the other databases add respectively 6336 and 4430 species by country records to those already listed by DAISIE. Only one out of twenty species by country records is shared among DAISIE and NOBANIS and one or more of the other 28 databases.

The complementarity is further explored separately for different environments and organism groups. Here, it should be noted that terrestrial species clearly outnumber aquatic species (Fig. 5a), and that plants and animals together make up more than 95% of the species listed as alien to one or more Member States of the EU or Norway (Fig. 5b).

(a)



(b)

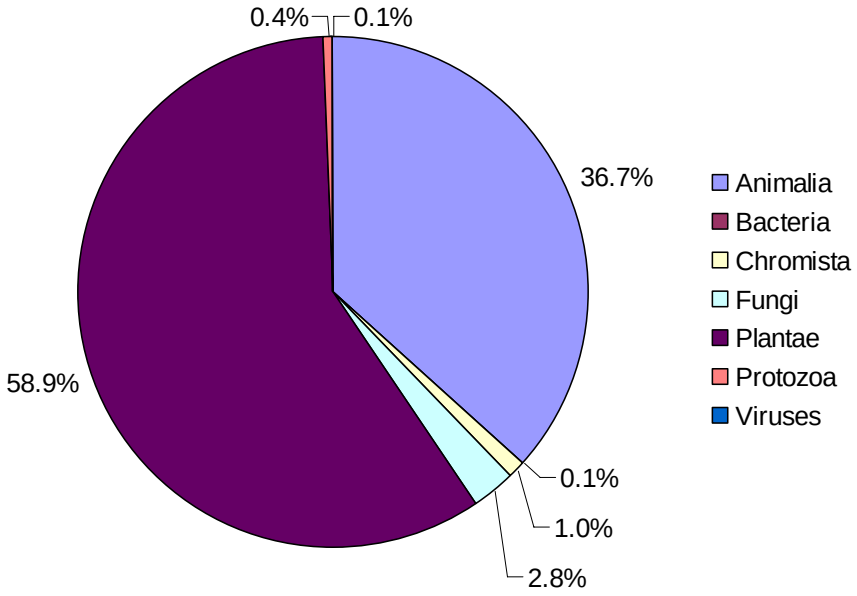


Figure 6: Pie charts showing the distribution of alien species across different (a) environments (TER: terrestrial, FW: freshwater, MAR: marine) and (b) organism groups (kingdoms).

Within the EU27 and Norway, DAISIE contains the highest number of species names, covering 64% (freshwater) to 72% (terrestrial) of the known aliens (Fig. 7). NOBANIS performs better for freshwater organisms (58%) and terrestrial organisms (51%) than for other organism groups (25%). The other databases have a limited coverage of terrestrial organisms (33%). Complementarity is relatively high, with only 45% (marine) to 59% (terrestrial) of the species names being shared among at least two databases. The focus of the databases becomes clearer when discriminating among organisms groups. The other databases are highly complementary to DAISIE and NOBANIS for organisms other and plants and animals (supplementary 47% of species names; Fig. 8).

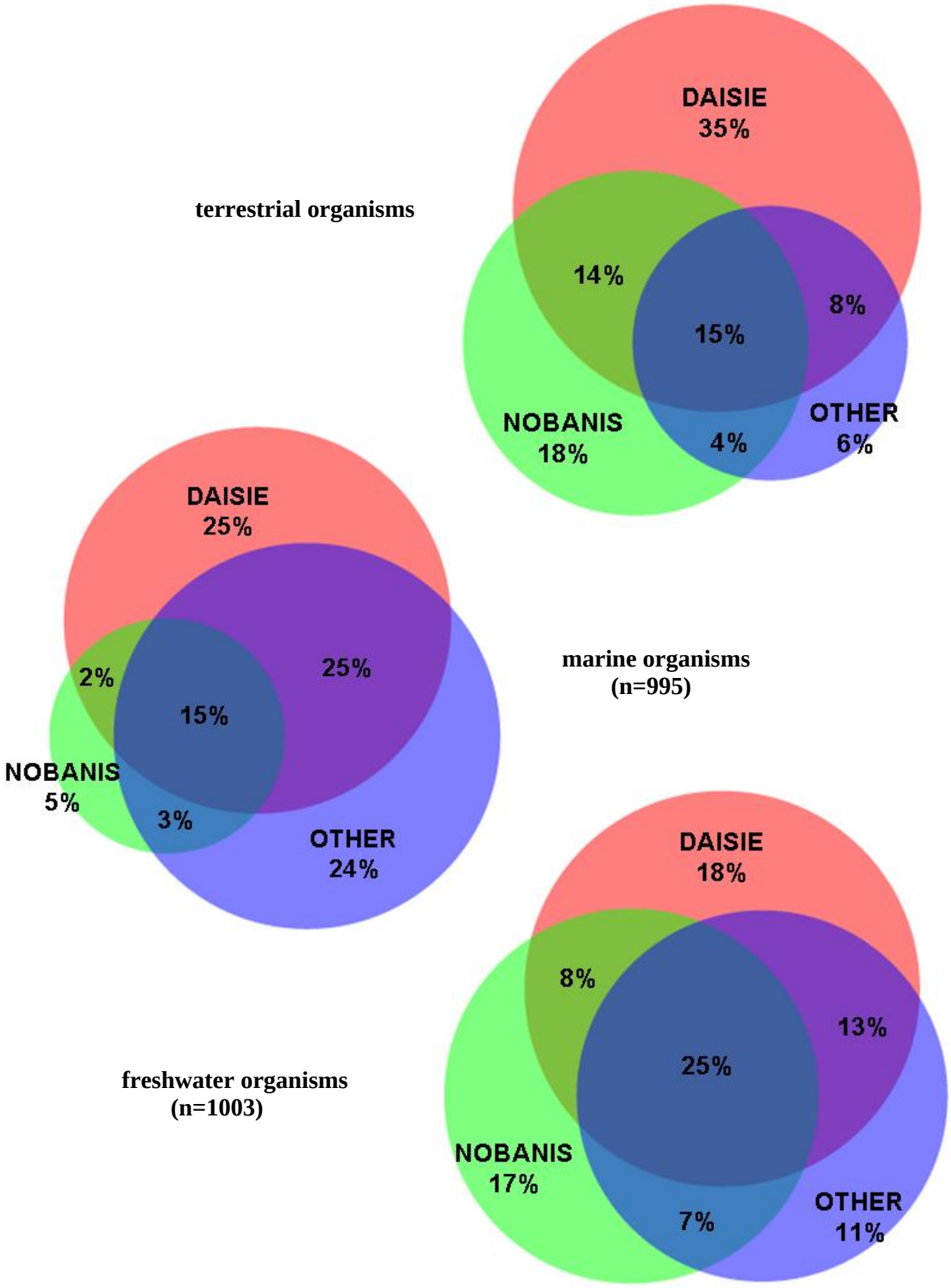


Figure 7: Venn diagrams showing the complementarity in species records for different environments among the databases DAISIE, NOBANIS and the combination of 28 other databases for the EU27 + Norway. Note that the sum or marine, freshwater and terrestrial organisms exceeds the total species number, because some species were allocated to multiple environments.

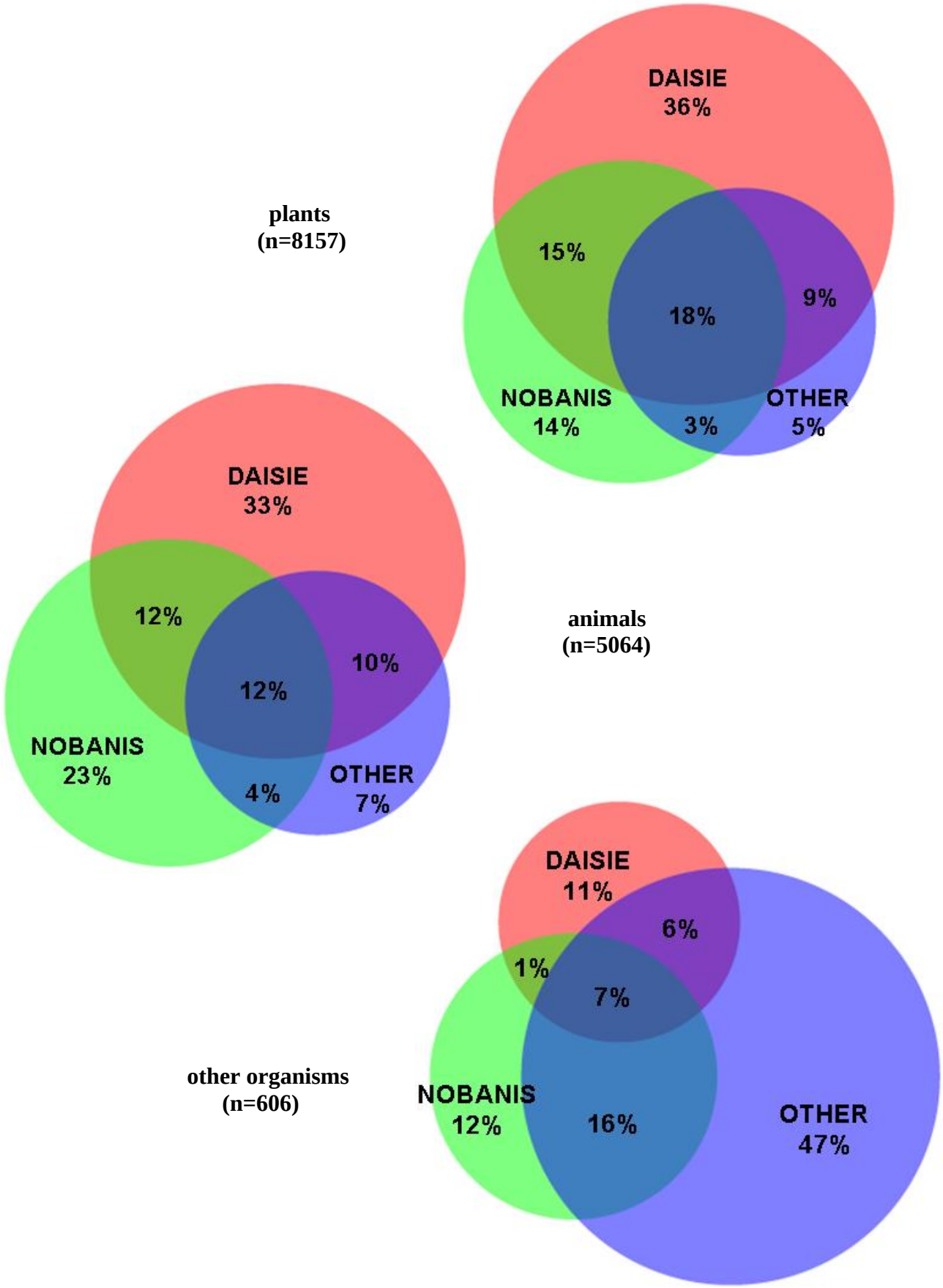


Figure 8: Venn diagrams showing the complementarity in species records across different organism groups among the databases DAISIE, NOBANIS and the combination of 28 other databases for the EU27 + Norway.

Figure 9 shows how the complementarity varies among countries. DAISIE lists between 47% (Denmark) and 97% (Belgium, Czech Republic, Portugal and Romania) of the species listed as alien by any of the databases (average over countries: 82%). NOBANIS covers Norway and 10 of the EU27 countries. For three of these countries, less than 20% of the known aliens are listed by NOBANIS (Belgium: 2%, Finland: 18%, Republic of Ireland: 1%). For the other countries, NOBANIS lists 59% (Lithuania) to 88% (Austria) of the known alien species (average: 75%). Six of these countries are better covered by NOBANIS than by DAISIE (Austria, Denmark, Estonia, Germany, Poland and Sweden). For Denmark, Estonia and Poland, NOBANIS lists between 50% and 80% more alien species than DAISIE. Other databases in general add relatively few alien species to those already listed by DAISIE and NOBANIS. Only for seven countries, over 10% of the known aliens are listed solely in one or more of the other, mainly national databases (Cyprus, Greece, Lithuania, Luxemburg, Republic of Ireland, Slovenia and the United Kingdom).

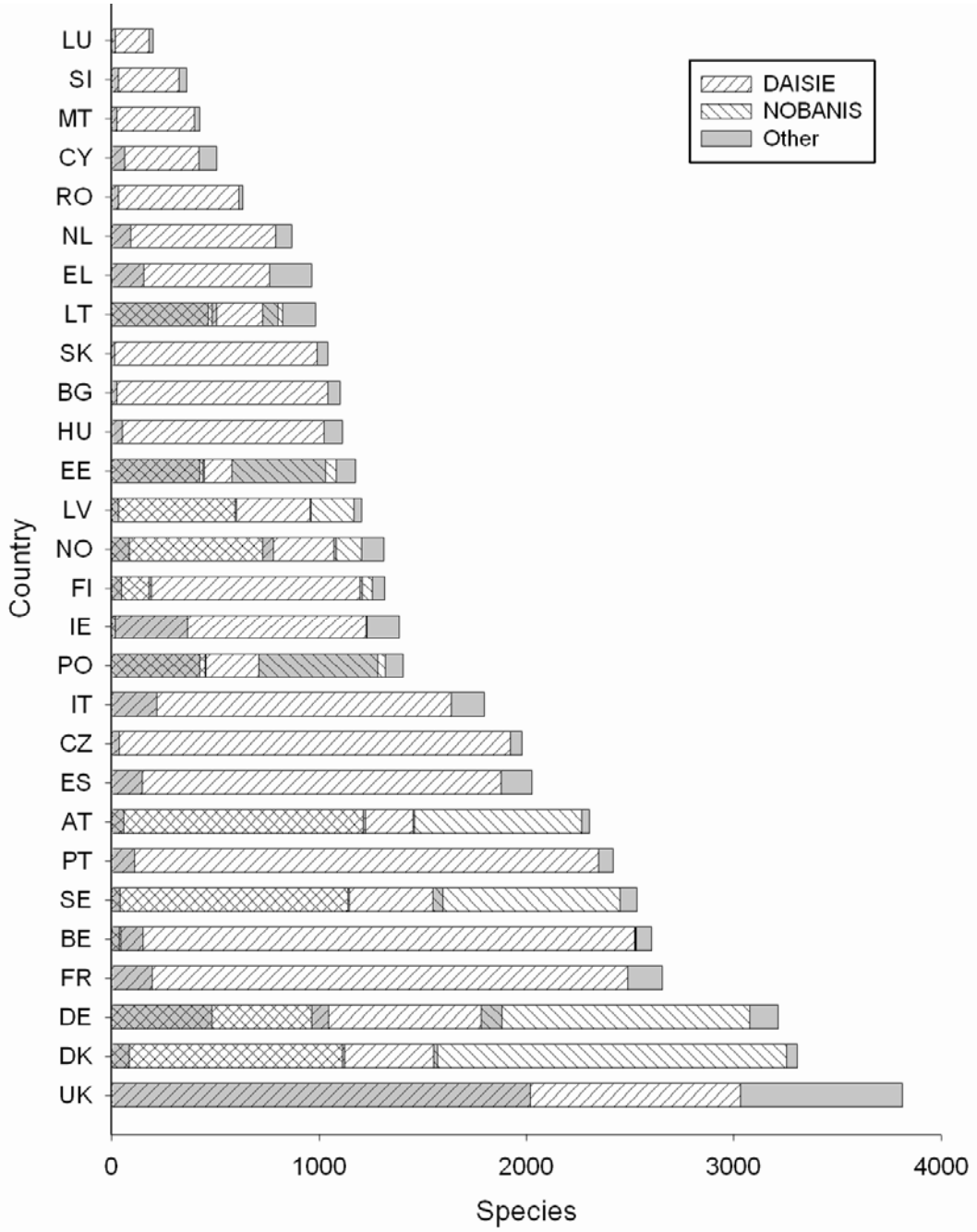


Figure 9: Bar chart showing the complementarity in species records among the two major European alien species databases (DAISIE and NOBANIS) and the combination of 28 other databases for each of the 27 EU Member States and Norway. Country codes as in Figure 2.

3. Compatibility

The merger of information on alien species from different databases is constrained for different reasons. A number of incompatibilities, such as different languages, coverages or scopes can be derived from the information provided in Annex 1. Here, we identify only those inconsistencies that may hamper the merging of country level presence/absence data of alien species: the definition of alien species and the notation of species names.

3a. Defining alien species

Of the thirty databases, only 17 explicitly defined which species were considered alien, invasive or invasive alien (Table 5). Most of these definitions stated that the introduction had to be mediated by man, including both intentional and accidental introductions (13 definitions). Two definitions explicitly excluded natural range expansions (due to global change). Three databases only considered as alien those species that were introduced after or before a certain data. Cut-off dates range from 6000 BC (UK) to 1960 (CIESM for Lessepsian migrants). Also the level of establishment of alien species is defined in very contrasting ways by the different databases. In most cases, a minimum level of establishment is needed before a species can be identified as alien, but for the CIESM atlases alien species are per definition 'exotic' species that have not been recorded more than once or twice. CIESM uses the term 'established exotic species' for more frequently recorded 'exotic species'. None of the alien species definitions require aliens to have an impact; this is only used to define invasive alien species.

Table 5: Criteria used (+) and not used (-) for defining 'alien', 'invasive' or 'invasive alien' species by the different databases. Only those databases for which alien species are explicitly defined are included in this table. Full database names and descriptions can be found in Annex 1.

Database	Period	Human	Impact	Establishment
DAISIE*	-	+ (direct or indirect)	-	-
NOBANIS*	-	-	-	+ (might survive and reproduce)
CIESM*	+ (>1960s, >1920s for Lessepsian species, >1950s for crustaceans)	-	-	+ (max. 1 or 2 records)
BE*	-	+ (intentional or accidental; excl. global warming)	-	-
BE-MAR*	-	+ (intentional or accidental)	-	+ (established populations)
DE-AQ*	+ (>1492)	+ (directly or indirectly)	-	+ (permanently living)
EL-MAR**	-	+ (deliberately or unintentionally)	+ (damage to biodiversity, human health, production, etc.)	+ (established and proliferating and spreading)
ES**	-	-	-	+ (excl. non-established species)
LT*	-	+ (intentionally or accidentally)	-	-

LU-PLANTS*	- (<1492: archaeophytes, >1492: neophytes)	+ (consciously or unconsciously, indirectly or directly; if no human mediation: agriophytes)	-	- (sporadically occurring: unstable, stable populations: established)
NO***	-	+ (human activities)	- (some threaten biodiversity)	-
PO*	-	+ (introduction: by human agency, direct or indirect)	-	+ (might survive and reproduce)
SE-MAR*	-	+ (with the help of humans; deliberate or accidental)	-	+ (spread)
UK*	+ (arrival of man; UK: 8000 BP)	+ (brought by man)	-	-
UK(E)*	-	+ (by human action; excl. man-introduced native species)	-	-
UK(N)**	-	+ (deliberately or unintentionally)	-	-
UK-MAR*	+ (not present in historical times)	+ (directly or indirectly by human agency, deliberately or otherwise; excl. natural range extension)	-	+ (established with self-maintaining populations)

* Alien species database, introduced species database, or non-native species database
** Invasive alien species database (synonym: invasive exotic species database)
*** Invasive species database

3b. Naming alien species

The species is the common denominator across the databases. Automated merging of information from different sources therefore requires a perfect matching of species names. Mismatches may arise from the use of synonyms, through typing errors, or variations and inconsistencies in notations. The latter is especially true for infraspecies aliens, such as subspecies or hybrids. Depending on the database, or even on the contributor to a certain database, the notation for subspecies can be written in full, deleted, or abbreviated to subsp., ssp. or ss. Prior to analysis, we reduced inconsistencies in notations by standardizing the notations for terms defining the infraspecies level. In addition, the compatibility was improved by removing or replacing special characters, removing names of authors and years, and trimming redundant spaces. The result is a list of 13827 'original' species names.

Of these 13827 'original' species names, 2211 (16%) were revised. The revision included a partial checking for species synonyms, spelling errors and infraspecies names that are not recognised by the Catalogue of Life, 2009. A description of the revision procedure is given in the Materials and Methods section.

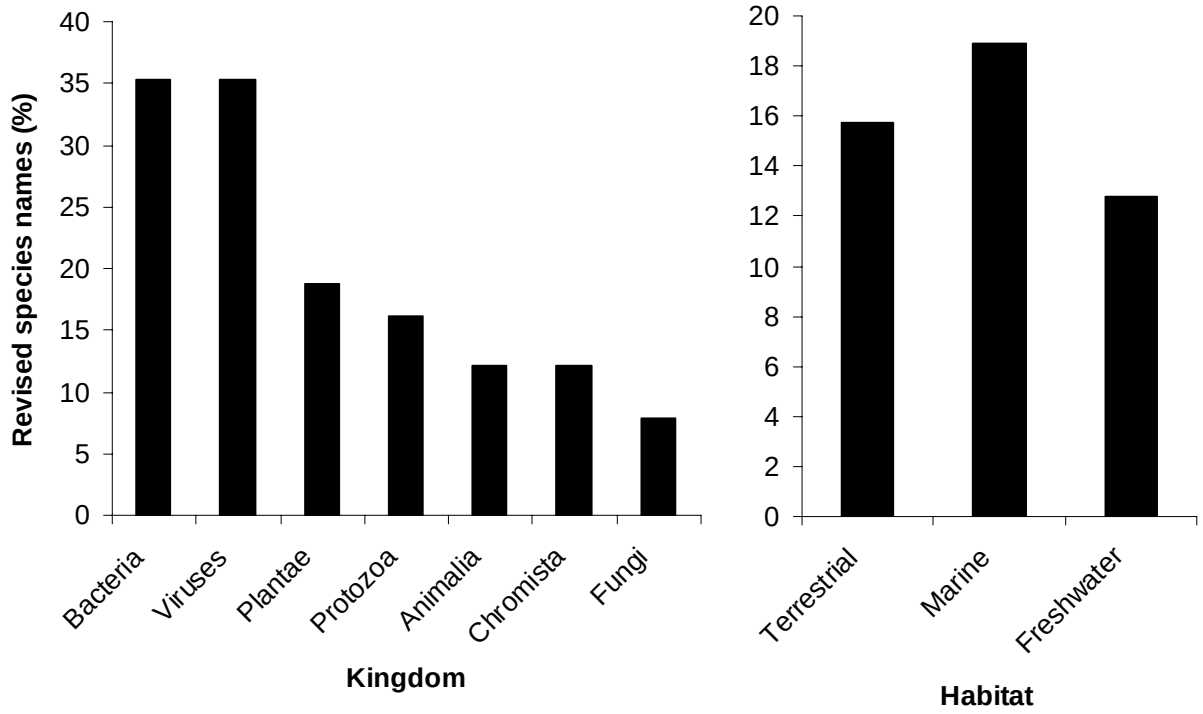


Figure 10: Fraction of original species names that were revised for different organism groups (a) and environments (b).

The fraction of species names that was revised was comparable between the databases DAISIE (12.4%) and NOBANIS (15.9%), which slightly exceeded the revisions carried out on the species names listed in the other databases (10.9%). Species names of bacteria and viruses were most often written incorrectly (35.3%; Fig. 10a). Also many names of alien plants were revised, usually by lumping unrecognised subspecies names to species level. Species names of marine organisms required more revision than those of freshwater organisms (Fig. 10b).

Discussion

Invasive alien species are increasingly recognized as a major threat to biodiversity (Bax et al., 2003, Pascal et al., 2010). In addition, there is an increased awareness of their potential economic damage, and the risk these species may pose to human health (Juliano & Lounibos, 2005, Pimentel et al., 2005, Cook et al., 2007). These recognitions urged authorities to draft strategies to prevent further introductions, and to control and eradicate introduced species. At the European level the development of an invasive species strategy is currently under debate (Shine et al., 2010). A crucial component of an effective strategy is an information platform that gives access to updated species distribution maps, risk and impact assessments and eradication or control measures. Such information systems were developed by many national authorities. In recent years a number of initiatives were taken to integrate and update the available information on species occurrences. This report explores the need and feasibility to further integrate information on alien species occurrences within the European Union.

1. Coverage

An unbiased coverage of alien species occurrences is crucial to researchers and policy makers. Researchers are using data on alien species distributions to improve our understanding of the process of introduction and establishment. For example, the recent study by Pysek et al. (2010) reviewed the distributions of key organism groups within Europe, largely based on the data collected within DAISIE, and concluded that the spatial variation in alien species numbers can largely be explained by national wealth and human population density. These insights, together with the alien species monitoring data, are then used by environment managers to optimize conservation efforts and minimize impacts. A criterion for targeting the conservation of European biodiversity is the cumulative number of alien species established in Europe (EEA/SEBI2010). Within the Marine Strategy Framework Directive, the conservation status of marine environments will be assessed by monitoring, amongst others, trends in the abundance, temporal occurrence and spatial distribution of aliens (Commission Decision 2010/477/EU).

The analysis of partially overlapping databases allowed identification of potential gaps in the coverage of alien species records. This gap analysis is challenging, because it implies discrimination between true and false absences. For example, does the underrepresentation of alien species in Eastern Europe reflect a disproportionally high exposure of western European countries to species introductions, or is this related to a geographic bias in monitoring and reporting efficiency? Similarly, the overrepresentation of terrestrial aliens compared to aquatic aliens, and of plants compared to other organism groups, does not necessarily imply a bias in the coverage of the databases. Nevertheless, there are a number of indications that the coverage of alien species occurrences is incomplete:

(1) Alien species records are available for all 27 EU Member States. However, very contrasting numbers of aliens are reported, ranging from 199 (Luxemburg) to nearly 4000 (UK). Striking differences were also found between neighbouring countries of comparable size (e.g. Belgium vs. The Netherlands: 2604 vs. 869 aliens; Sweden vs. Finland: 2531 vs. 1316 aliens).

(2) Another indication for a geographical bias in the coverage is the spatial heterogeneity in the distribution and extent of national databases. Online ‘national’ databases with alien species occurrences were available only for 15 countries, and the majority of these were limited to a particular region (e.g. England), organism group (e.g. plants) or environment (e.g. marine). National databases were not existing or not accessible for most Eastern European countries. On the other hand, alien species numbers in national databases did not correlate significantly with those in regional databases, like DAISIE and NOBANIS, suggesting that national databases are not the main data source for integrated regional databases.

(3) Also the distribution and scope of regional and thematic databases is biased. The most extensive regional database is limited to Northern and Central European countries (NOBANIS), and others are focusing on marine environments (CIESM, Baltic Sea Alien Species Database) or particular organism groups (AVIBASE: birds, FISHBASE: fish, PQR: pests and plants).
(4) Overall, DAISIE is the most comprehensive resource for alien species occurrences in Europe. On average, DAISIE lists 82% of all species known to be alien in a country based on the information retrieved from thirty online databases. The relative performance of DAISIE is strongly reduced in the NOBANIS countries. For the seven countries that are best covered by NOBANIS, DAISIE only lists on average 57% of the alien species. This suggests that the absolute performance of DAISIE in the other countries rather reflects the lack of good alternative resources rather than a superior coverage by DAISIE in these countries.

Ideally, monitoring and reporting effort should be harmonized across countries and regions. In the absence of a standardised European monitoring scheme for aliens, efforts can be focused on particular organism groups and habitats. For Europe, such focused efforts exist for fish (FishBase), birds (Avibase) and pests and invasive plants (EPPO Plant Quarantaine Retrieval System). Although these databases typically target only a small fraction of the total number of aliens, they may provide good indications of the variation among countries in alien species numbers. Our correlations suggest that numbers of introduced birds and pests/invasive plants offer a good proxy for the richness of aliens in general. Interestingly, the spatial variation in alien species matches well that of the 163 worst aliens, providing an additional argument to focus on these high-impact species.

2. Complementarity

The key objective of this study was to assess complementarity in alien species records among existing databases, and as such the added value of integrating or cross-linking existing alien species databases at EU level.

The project-based database DAISIE continues to be the most comprehensive resource for alien species in Europe, also after the termination of the project in January 2008. The complementarity of DAISIE with other databases is relatively low. One third of the alien species names listed in DAISIE is unique to this database. Of all species that are known to be alien to one or more EU Member States, only 15% is shared among DAISIE, NOBANIS and any other database. Nearly 4000 species are listed as alien in one or more of the databases, and are absent in the DAISIE database. NOBANIS is most complementary to DAISIE for species names of terrestrial and freshwater organisms (resp. 22% and 24%), and animals (23%), while other databases supplement DAISIE primarily with marine species names (27%) and organisms other than plants and animals (47%).

The complementarity is even higher when discriminating between countries: more than half of the species by country records is unique to DAISIE, and only one out of every twenty species by country records is shared among at least three databases. In particular for the Northern European there is a large benefit in merging species occurrences from different resources. This is due to the high complementarity of DAISIE with NOBANIS and the Baltic Sea Alien Species database. Such regional initiatives are absent in Eastern Europe, and only partially present in Southern Europe (CIESM atlases for marine organism groups in Mediterranean basin).

Many countries have developed national databases. Although these can contain a substantial number of species names, they add in general only few names to DAISIE or NOBANIS. This is not surprising as some of these databases form the basis for larger-scale initiatives. In addition, many national databases are limited to invasive alien species. It should be stressed that the national databases together with

some biodiversity databases and databases targeting a particular organism group are currently also the main source for georeferenced occurrences of alien species in Europe. Other advantages of many national databases are their frequency of updating, and the amount of information provided in the species fact sheets.

3. Compatibility

We focused on two sources of incompatibility that complicate the merging of species occurrence records from existing databases: differences in defining which species are included, and variations in species name notations.

For this report, alien species occurrences were extracted from alien species databases, invasive species databases, general biodiversity databases, and a database combining information on pests and invasive plants species. Most databases adopted the definitions provided by the International Union for Conservation of Nature (IUCN)[1] and the Convention on Biological Diversity (CBD)[2]. The CBD defines an alien species as "A species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce. The IUCN added to this definition that the species should not only be introduced outside of its natural range, but also outside its dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans). Most databases follow the key criterion that the introduction has to be mediated by humans, either intentionally or intentionally. Only few specify that this excludes species that expanded their range as a result of climate change. Most databases also list 'new'-comers regardless of the date of their introduction, while others specify a cut-off date. These cut-off dates range from 8000 BP to 1960, and are determined by ecological relevance and the availability of a reference. Databases targeting invasive alien species and invasive species usually specify the need for a (potential) impact, thereby following the CBD and IUCN terminology ("species whose introduction and/or spread threatens native biological diversity"). There is no consensus across these databases neither on the nature nor on the magnitude of the (potential) impact. Also, invasive species databases tend to consider only alien species as potentially invasive, whereas also native species may become invasive in response to anthropogenic changes in the environment (Valérie et al., 2009). Valérie et al. (2008) made abstraction of both the impact and the geographic criterion to define invasive species, and argued that a fundamental attribute of any invasive species is the superiority of its response over those of functionally similar species, as this is what leads to its dominance or to its invasion. In this view, an invasive species is always alien to its novel environment, either because of a change OF the environment (alien species) or because of a change IN the environment (native species or alien species that spread after a lag time).

Ideally, definitions for alien and invasive alien species are both ecologically relevant and practical. For example, one could argue that 1869 is a good cut-off date to identify aliens in the Mediterranean Sea, as it coincides with the opening of the Suez Canal. In practice, 1920 may be a better date, as in this year a major scientific expedition inventoried many species in the region. A practical definition also needs to be specific. It is not sufficient to say that an invasive species has an impact; one should also describe the nature of the impact (e.g. on biodiversity, human health, economy), and if possible also the magnitude. Without a precise definition, the identification of alien and invasive alien species will remain subjective.

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[1] IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species (2000). Approved by the IUCN Council, Feb 2000.

[2] CBD Decision VI/23* of the Conference of the Parties to the CBD, Annex, footnote to the Introduction.

The species name should be the common denominator across databases. In practice, the merging of information on alien species from multiple sources is hampered by variations in species name notations. Some databases include the author name and year of description, while others don't. Also abbreviations for infraspecies name notations lack standardisation (e.g. subspecies: subsp., ssp., ss., etc.). Contributors also upload misspelled names and species synonyms. Tools are becoming available for automated revision of species names based on vast collections of species names (e.g. WoRMS taxon matching tool: http://www.marinespecies.org/aphia.php?p=match, Global Names Index: http://gni.globalnames.org/). A more efficient approach would be to create lists of accepted species names in a standardized format, from which contributors can select names.

Conclusions and recommendations

Our comparative analysis of occurrence data across 30 online databases with alien species records uncovers a high degree of complementarity of information. The most comprehensive resource for country level alien species occurrences in Europe (DAISIE) fails to report about one out of every four species known to be alien to one or more countries within the EU27 + Norway territory. When accessing only a single database, a minimum of 10,000 species by country records stay unaccounted for at European level. The distributed and largely independent nature of existing alien species information systems has multiple consequences:

i. In the absence of an overarching data exploration system, it complicates the retrieval of information, and the identification of knowledge gaps
ii. It allows systems to diverge and as such become less compatible
iii. It potentially makes inefficient use of existing financial and intellectual resources.

This study aimed at quantifying the complementarity in species records across multiple online information species, without accounting for variations in the quality of the delivered data. Most databases have an internal quality revision, which relies on contributions from a network of experts. Many of these contributions are made on a voluntary basis, without financial compensation. A sustainable and yet cost-effective mechanism to support expert contributions is to attach author rights to them. This approach is successfully adopted by the journal Aquatic Invasions, which has already encouraged many experts to share their knowledge of alien species introductions. Access to published records is facilitated by the development of an online, GIS-based search and mapping tool (see Panov and Gollasch, 2006 and the journal web site at http://www.aquaticinvasions.net). With recent establishment in Europe of one more thematic open-access journal on biological invasions (NeoBiota – see http://www.pensoft.net/journals/neobiota), a similar cost-effective tool is now potentially available also for information systems covering terrestrial IAS.

The majority of the international databases provided occurrence data at country or regional (island) level (GISD, DIAS, Avibase, PQR, DAISIE, NOBANIS). The Baltic Sea Alien Species Database list occurrences at sea basin grain and the CIESM atlases provide high resolution distribution ranges and occasional point records. Fishbase is a major source of georeferenced occurrence records, also for introduced species, but is obviously limited to a single organism group and to aquatic environments. Increasing the spatial resolution of occurrence data in integrated databases would have a large added value. It would allow identification of pathways and potentially a more targeted response at management level. Georeferenced occurrence records can also be aggregated at scales that are more relevant to particular policies, such as the river basin scale for the EU Water Framework Directive.

The lack of geo-referenced records of alien species was already highlighted in the first review of online European information systems, focusing on aquatic aliens (Panov & Gollasch, 2004). That review also revealed that at the time, the information provided by the existing information systems was insufficient for management purposes. More efforts are needed to increase the spatial resolution of

alien species databases. This can be done in a cost-efficient way by filtering information from general biodiversity databases (e.g. GBIF, BioFresh), by linking to journal supplements (e.g. NeoBiota, Aquatic Invasions), or by querying data from biological monitoring surveys. A more ambitious and complementary approach is to set-up a pan-European surveillance network for alien species that links directly to one or more information platforms.

The distributed location of information complicates its retrieval at pan-European level. The FP6 project DAISIE attempted to remediate this by integrating all information into a single information system. Our study shows that this database is still the most comprehensive in Europe in terms of national level alien species occurrences, despite the termination of the project more than three years ago. On the other hand, there are strong indications that despite occasional updates DAISIE is at present no longer a sufficient source of information (this study, Zenetos & Polychronidis, 2010). Furthermore, the absence of georeferenced records, together with the doubtful nature of at least some of the DAISIE records force us to reconsider the data centralisation approach.

An alternative approach to increase the accessibility of information is to create a network of online interoperable web services through which information in distributed resources can be accessed. This concept was realized in the early 2000s, with the establishment of the virtual Regional Biological Invasions Centre (RBIC). RBIC served as a thematic regional hub, linking all European online information resources on aquatic invasive species. During 2001-2006, RBIC web site also hosted the first European on-line GIS-based information platform with geo-referenced record data on aquatic invasive species. The platform linked to species fact sheets (AquaInvader information system) and to the first Alien Species Expert Registry (European Research Network on Aquatic Invasive Species; ERNAIS). With the support of FP6 (ALARM) and FP7 (enviroGRIDS) projects, this information platform has been developed further into the Regional Euro-Asian Biological Invasions Centre information system (http://www.reabic.net).

A similar approach as the one developed by REABIC could be adopted at the European scale, encompassing all environment types. The successful implementation of such ambitious concept relies on (1) continued engagement at national and regional scale to collect and provide data; (2) the willingness of database managers to harmonize their information (3) the development of a set of interoperable web services through which the information can be explored; and (4) appropriate and sustainable funding to allow for (1) to (3). In the longer term, this approach would increase the availability and accessibility of information on alien species, and ultimately support a cost-efficient invasive alien species policy.

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Annex 1: Database descriptors

I. GLOBAL

1. GISD

Full name: Global Invasive Species Database (GISD)

Management: Invasive Species Specialist Group (ISSG) of the IUCN-World Conservation Union

Maintenance: regular

Contact: issg@auckland.ac.nz

Weblink: http://www.issg.org/database/welcome/

Coverage

- Geographical coverage: global
- EU Member States: EU-27
- Alien taxa: 678 species (355 in EU-27 + Norway)
- Organism groups/environments: all
- Resolution: country/location

Data sources

- Network of experts

Accessibility

- Search engine (species x country x environment x organism group)
- No data export module
- In English

Species information

- Impact: location specific impacts + detailed species factsheets
- Establishment: categorized (invasive, not invasive, not specified)
- Measures: location specific information + links to ISSG management options for species
- Year of introduction: no (date of publication)
- Pathway of introduction: species specific information in species fact sheet
- Taxonomy: Full taxonomy
- Synonyms: yes
- Common names: yes
- Ecology (habitat): detailed species fact sheets
- Referenced occurrences: yes (publication)
- Coordinates: no (but name of location; e.g. Great Barrier Reef)

Notes

- The data collected by GISD are being fed into GISIN (Global Invasive Species Information System)
- Contains a 100 worst list

2. DIAS

Full name: Database on Introductions of Aquatic Species

Management: Food and Agriculture Organization of the United Nations

Maintenance: unknown

Contact: FI-Inquiries@fao.org

Weblink: http://www.fao.org/fishery/introsp/search/en

Coverage

- Geographical coverage: global
- EU Member States: EU-27
- Alien taxa: unknown (5612 introductions, 355 species in EU-27 + Norway)
- Organism groups/environments: mostly freshwater fish + some molluscs, crustaceans, and marine species.
- Resolution: country

Data sources

- Voluntary contributions

Accessibility

- Species search engine and categorized listing (country x status x impact x etc.)
- No data export module
- In English

Species information

- Impact: ecological and socioeconomic effects (categorized)
- Establishment: categorized (established, probably established, probably established, not established, unknown)
- Measures: no information
- Year of introduction: yes
- Pathway of introduction: yes (if known)
- Taxonomy: no
- Synonyms: no
- Common names: no
- Ecology (habitat): no information
- Referenced occurrences: yes (to person or publication)
- Coordinates: no

Notes

- DIAS provides for many introduced species the country of origin.

3. FishBase

Full name: FishBase: a Global Information System on Fishes

Management: World Fish Centre + 8 other organisations

Maintenance: Continuous

Contact: Christian Elloran (webmaster: c.elloran@cgiar.org)

Weblink: http://www.fishbase.org/home.htm

Coverage

- Geographical coverage: global (303 countries/islands)
- EU Member States: EU-27
- Alien taxa: unknown (154 in EU-27 + Norway)
- Organism groups/environments: fish
- Resolution: country/island + site

Data sources

- Global network of collaborators + databases (incl. GBIF)

Accessibility

- Flexible search engine (species, country, habitat, use, etc.)
- Data export module for species (xml; summary page, point data, common names and photos)
- In many languages

Species information

- Impact: Categorized threat to humans + description of ecology
- Establishment: categorized (unknown, established, probably established, not established)
- Measures: no
- Year of introduction: no
- Pathway of introduction: no
- Taxonomy: Kingdom – Phylum – Class - Order - Family
- Synonyms: yes
- Common names: yes (many languages)
- Ecology (habitat): categorized + description
- Referenced occurrences: yes (to person or database)
- Coordinates: yes

Notes

- FishBase is not designed as an alien species database, but allows filtering out introduced species per country.
- For marine fish species, environmental envelopes are modelled with AquaMaps, and used to identify suitable habitats. These models are matched against climate change scenarios to outline future geographical ranges for marine species (year 2050).

4. Avibase

Full name: Avibase - Bird Checklists of the World

Management: Bird Studies Canada

Maintenance: regular

Contact: Denis Lepage (dlepage@bsc-eoc.org)

Weblink: http://avibase.bsc-eoc.org/checklist.jsp?lang=EN

Coverage

- Geographical coverage: global (ca. 220 countries/islands)
- EU Member States: bird lists are available for al 27 Member States, but no introduced species are reported for Estonia, Malta and Cyprus
- Alien taxa: unknown (39 species in EU-27 + Norway)
- Organism groups/environments: birds
- Resolution: country/island/(subnational) region

Data sources

- International network of contributors

Accessibility

- Species search engine and country specific listing
- No data export module
- In English

Species information

- Impact: no information
- Establishment: no information for introduced species
- Measures: no information
- Pathway of introduction: no information
- Taxonomy: Order - Family
- Synonyms: yes
- Common names: yes (many languages)
- Ecology (habitat): no information
- Referenced occurrences: no
- Coordinates: no

Notes

- Avibase is a biodiversity database, which discriminates between native and introduced species.

5. PQR

Full name: Plant Quarantine Data Retrieval System (PQR)

Management: Secretariat of EPPO (European and Mediterranean Plant Protection Organization)

Maintenance: regular

Contact:
http://www.eppo.org/tools/commentpage.htm?l=aHR0cDovL3d3dy5lcHBvLm9yZy9EQVRBQkFTRVMvcHFyL3Bxci5odG0=

Weblink: http://www.eppo.org/DATABASES/pqr/pqr.htm

Coverage

- Geographical coverage: global (251 countries)
- EU Member States: EU-27
- Alien taxa: 2662 pests (not necessarily alien; see Materials and Methods for details) (323 alien pests and introduced plants in EU-27 + Norway)
- Organism groups/environments: pests (mostly insects, fungi and viruses) and plants
- Resolution: countries

Data sources

- National authorities reporting to EPPO + CABI maps

Accessibility

- Species, host or country/region search
- No data export module
- Free program needs to be downloaded to access the data (or CD-ROM for 75 Euro)
- In English

Species information

- Impact: pests: categorized (absent vs. present in EPPO region); alien plants: list of plant species that pose a threat to plant health, environment and biodiversity in the EPPO region
- Establishment: pests: categorized (pests: few records, limited distribution, widespread or no details available; alien plants: invasive or potentially invasive)
- Measures: no information in database
- Year of introduction: no
- Pathway of introduction: List of commodities able to act as pathways in international trade
- Taxonomy: full taxonomy
- Synonyms: yes
- Common names: yes (English)
- Ecology (habitat): list of possible hosts for pests
- Referenced occurrences: yes (to national EPPO reporting authority)
- Coordinates: no

Notes

- Species factsheets are available on the EPPO site for quarantine pests, which are aligned to those in the CAB International (CABI) Crop Protection Compendium.

II. EUROPEAN

6. DAISIE

Full name: Delivering Alien Invasive Species Inventories for Europe

Management: Project-based (FP7 project DAISIE)

Maintenance: regular

Contact: daisie@ceh.ac.uk

Weblink: http://www.europe-aliens.org/

Coverage

- Geographical coverage: Europe and surroundings (63 countries)
- EU Member States: EU-27
- Alien taxa: 10961 (9843 in EU-27 + Norway)
- Organism groups/environments: all
- Resolution: countries, subnational regions (islands), and seas

Data sources

- Experts (44 institutes in 31 countries) and databases (e.g. NOBANIS)

Accessibility

- Species search engine and categorized listing (country x environment (terrestrial, freshwater or marine) x organism group)
- No data export module
- In English

Species information

- Impact: Ecosystem, health and societal and economic impact (description; for subset only) + 100 worst list
- Establishment: categorized (established, unspecified, unknown, extinct, not established)
- Measures: text description (for subset only)
- Year of introduction: no
- Pathway of introduction: yes (if known)
- Taxonomy: Kingdom – Phylum – Class - Order - Family
- Synonyms: yes
- Common names: yes (many languages)
- Ecology (habitat): categorized (aquatic inland, marine and terrestrial + description)
- Referenced occurrences: yes (to person or database)
- Coordinates: no

Notes

- Detailed species accounts for '100 worst' invasive aliens in Europe
- Extensive directory of expert

7. NOBANIS

Full name: North European and Baltic Network on Invasive Alien Species

Management: NOBANIS network of national focal points

Maintenance: regular

Contact: nobanis@sns.dk

Weblink: http://www.nobanis.org/

Coverage

- Geographical coverage: Northern and Central Europe (19 countries)
- EU Member States: 11 (239-2258 species for Denmark, Estonia, Germany, Finland, Latvia, Lithuania, Norway, Poland and Sweden; Belgium: 51 species; Ireland: 20 species)
- Alien taxa: > 6000 species (6876 in EU-27 + Norway)
- Organism groups/environments: all
- Resolution: countries

Data sources

- National databases, experts and alien species projects and programmes

Accessibility

- Species search engine and categorized listing (country x environment x organism group)
- No data export module
- In English

Species information

- Impact: invasive, potentially invasive, not invasive, not known, not reported; details in factsheets for subset of species
- Establishment: categorized (very common, common, local, rare, not known, eradicated, extinct); details in factsheets for subset of species
- Measures: text description in species factsheets
- Year of introduction: history of spread in factsheets for subset of species
- Pathway of introduction: details in factsheets for subset of species
- Taxonomy: Full taxonomy
- Synonyms: yes
- Common names: yes (many languages)
- Ecology (habitat): details in factsheets for subset of species
- Referenced occurrences: link to paper or database
- Coordinates: no

Notes

- On website a catalogue of regulations relevant to invasive species in participating countries
- Extensive literature database connecting to regional and global networks and projects on invasive aliens species.

8. CIESM

Full name: CIESM Atlas of Exotic Species in the Mediterranean

Management: The Mediterranean Science Commission (CIESM)

Maintenance: regular

Contact: contact@ciesm.org

Weblink: http://www.ciesm.org/online/atlas/index.htm

Coverage

- Geographical coverage: Mediterranean Basin (22 countries)
- EU Member States: 7 countries
- Alien taxa: 432 (246 in EU-27)
- Organism groups/habitat types: marine fish, crustacean decapods and stomatopods, molluscs and macrophytes
- Resolution: countries + distribution ranges + point records

Data sources

- Experts and literature

Accessibility

- List of species per organism group, with categorized origin and status, and date of last update
- No export module for species records, PDF download of references
- In English

Species information

- Impact: no systematic reporting
- Establishment: short description in species fact sheets
- Measures: no systematic reporting
- Year of introduction: yes (1st record in Mediterranean)
- Pathway of introduction: yes (if known)
- Taxonomy: (Order -) Family
- Synonyms: yes
- Common names: yes (many languages)
- Ecology (habitat): description in species fact sheets
- Referenced occurrences: yes (list of publications)
- Coordinates: no

Notes

- Detailed fact sheets for all species
- Extensive an downloadable atlas bibliographies
- Contains also a list of species excluded from the atlases (misidentifications)
- Since September 2004 the CIESM database is integrated in NIS-base (global Non-Indigenous Species database managed by the Smithsonian Institute)

9. Baltic Sea

Full name: Baltic Sea Alien Species Database

Management: Baltic Marine Biologists Working Group on Nonindigenous Estuarine and Marine Organisms (S. Olenin, E. Leppäkoski, D. Daunys)

Maintenance: regular

Contact: http://www.corpi.ku.lt/nemo/feedback.html

Weblink: http://www.corpi.ku.lt/nemo/balt_reg.html

Coverage

- Geographical coverage: Baltic Sea
- EU Member States: 8 (Denmark, Germany, Estonia, Finland, Latvia, Lithuania, Poland, Sweden)
- Alien taxa: 119 (113 at moment of data extraction)
- Organism groups/environments: marine species
- Resolution: basin/lagoon

Data sources

- Experts, publications (papers, environmental reports, “grey literature”), internet sites, database questionnaire

Accessibility

- species search + categorized database search (organism group x functional group x vector x origin x year of first introduction x salinity range Baltic Sea x salinity rang native region x ecological impact x impact on uses/resources + literature search + subregion search
- No data export module
- In English

Species information

- Impact: categorized, multilevel (ecological impact: 13 categories; impact on uses/resources: 8 categories) + details in species fact sheets
- Establishment: categorized (established, not established)
- Measures: no information
- Year of introduction: available for most species (or decade/century)
- Pathway of introduction: categorized, multilevel
- Taxonomy: 23 taxonomic groups
- Synonyms: no
- Common names: no
- Ecology (habitat): Baltic Sea, salinity range, details in species fact sheets
- Referenced occurrences: list of references in species factsheets
- Coordinates: no

Notes

- Linked to BINPAS (automated biological invasion impact / biopollution assessment system)
- Species factsheets linked to databases (e.g. FishBase, Caspian Sea Biodiversity database)

III. NATIONAL

10. AT

Full name: Austrian Biodiversity Information System (OASIS 2.0 ; 'Österreichisches Artenschutz-Informationssystem')

Management: Austrian Federal Environment Agency (Umwelt Bundesamt Austria)

Maintenance: regular

Contact: naturschutz@umweltbundesamt.at

Weblink: http://www.umweltbundesamt.at/oasis

Coverage

- Geographical coverage: Austria
- EU Member States: 1
- Alien taxa: 16
- Organism groups/environments: mammals, birds, reptiles, amphibians, fish, odonates, lepidopterans, molluscs
- Resolution: 15 Austrian regions

Data sources

- Publications

Accessibility

- Species search engine + categorized search (organism group x region x status; most recent version without identification of introduced species)
- No data export module
- In German

Species information

- Impact: no information
- Establishment: no further information for introduced species
- Measures: no information
- Year of introduction: not available
- Pathway of introduction: no information
- Taxonomy: 9 taxonomic groups
- Synonyms: no
- Common names: German and English
- Ecology (habitat): no information
- Referenced occurrences: at species level link to source publication
- Coordinates: no

Notes

- Biodiversity database, but with identification of alien species
- Link to book 'NeoBiota in Österreich' (Franz Essl, 2002) (PDF, details for 1492 aliens)

11. BE

Full name: Harmonia database (Invasive Species in Belgium)

Management: Belgian Forum on Invasive Species

Maintenance: regular

Contact: http://www.biodiversity.be/contact/index

Weblink: http://ias.biodiversity.be/ias/

Coverage

- Geographical coverage: Belgium
- EU Member States: 1
- Alien taxa: 93
- Organism groups/environments: all
- Resolution: biogeographic areas (subnational)

Data sources

- Voluntary contributions (literature)

Accessibility

- 19 organism group x 4 environments (marine, brackish, freshwater, terrestrial) x 11 statuses (alert, black and watch lists)
- No data export module
- In English

Species information

- Impact: categorized (4 impacts on species and 4 impacts on ecosystems); description in species fact sheet
- Establishment: categorized at species level (isolated populations; restricted range; widespread)
- Measures: no information
- Year of introduction: first observation in Belgium
- Pathway of introduction: yes
- Taxonomy: 19 organism groups + family
- Synonyms: no
- Common names: English, French, Dutch
- Ecology (habitat): 4 environments + some information in species fact sheet
- Referenced occurrences: at species level links to contributors and reference list
- Coordinates: no

Notes

- Search engine for national and international alien species projects
- Overview of international specialist working groups and databases and information networks

12. BE-MAR

Full name: Checklist for aquatic alien species in the Belgian part of the North Sea and adjacent estuaries

Management: Flanders Marine Institute (VLIZ)

Maintenance: unknown

Contact: info@vliz.be

Weblink: http://www.vliz.be/EN/Figures_Policy/nietinheemsLIJST

Coverage

- Geographical coverage: Belgian part of the North Sea and adjacent estuaries
- EU Member States: 1 (Belgium)
- Alien taxa: 68
- Organism groups/environments: marine + brackish water species
- Resolution: Country

Data sources

- Contributors (species specific; + links in species fact sheets to World Register of Marines Species (WORMS), NOBANIS, DAISIE, GISD)

Accessibility

- Hyperlinked species list, organized per organism group
- No data export module
- In English

Species information

- Impact: description in species fact sheet
- Establishment: description in species fact sheet
- Measures: no information
- Year of introduction: given in species fact sheet
- Pathway of introduction: description in species fact sheet
- Taxonomy: 12 organism groups
- Synonyms: no
- Common names: for some species Dutch and/or English name
- Ecology (habitat): description in species fact sheet
- Referenced occurrences: at species level (name of contributor)
- Coordinates: no

Notes

- The list does not cover alien species that were reported along the Belgian coast but failed to establish permanent populations, nor species that expanded their range naturally

13. DE-AQ

Full name: Aquatic alien species in German Inland and Coastal Waters

Management: AeT Environmental Planning (Aqua et Terra (AeT) Umweltplanung)

Maintenance: regular (last update: July 2010)

Contact: Stefan Nehring (info@stefannehring.de)

Weblink: http://www.aquatic-aliens.de/species-directory.htm

Coverage

- Geographical coverage: Germany
- EU Member States: 1
- Alien taxa: 131
- Organism groups/environments: aquatic species (marine + freshwater)
- Resolution: 3 categories (inland, Baltic, North Sea)

Data sources

- Literature (31 key references)

Accessibility

- Online table with for each species, organized per organism group, the origin, vector, ate distribution, status and key reference
- No data export module
- In English

Species information

- Impact: no information
- Establishment: categorized (few localities, part of area, throughout area)
- Measures: not available at species level, but general information available
- Year of introduction: first record in the wild specified
- Pathway of introduction: categorized
- Taxonomy: 7 major organism groups subdivided in 38 taxonomic groups
- Synonyms: no
- Common names: no
- Ecology (habitat): freshwater vs. marine
- Referenced occurrences: at species level linked to key references
- Coordinates: no

Notes

- Links to key references and databases

14. DE-PLANTS

Full name: FloraWeb

Management: Federal Office for Nature Conservation (‘Bundesamt fur Naturschutz’)

Maintenance: Irregular (last update July 2009)

Contact: floraweb@bfn.de

Weblink: http://www.floraweb.de/pflanzenarten/eigenschaften_treffer.xsql

Coverage

- Geographical coverage: Germany
- EU Member States: 1
- Alien taxa: 495
- Organism groups/environments: plants
- Resolution: ca. 10 x 10 km

Data sources

- Continuous monitoring campaign (start: 1970; coordination: ‘Sektion Florenkartierung des Vereins NetPhyD (Netzwerk Phytodiversität Deutschlands) am saarländischen Zentrum für Biodokumentation’
- National plant database FlorKart of the Federal Office for Nature Conservation

Accessibility

- Hyperlinked species list, organized alphabetically
- No data export module
- In German

Species information

- Impact: no information
- Establishment: occurrence grid with ca. 10 x 10 km resolution; 34 species recognized as invasive
- Measures: no information
- Year of introduction: observations or categorized in 3 periods (pre 1950, 1950-1980, post 1980)
- Pathway of introduction: no information
- Taxonomy: full taxonomy
- Synonyms: no
- Common names: German
- Ecology (habitat): detailed information in tabbed species fact sheets
- Referenced occurrences: no
- Coordinates: not accessible, but GIS-based mapping tool allows display of occurrences at 10x10 km grid for different periods

Notes

- Biodiversity database with easy extraction of neophytes and cultivated plants
- Linked to active forum on neophytes in Germany (19 October 2010: 179 contributions)

15. DK

Full name: Danish Database of Introduced Species (‘*Database over Introducerede Arter’*)

Management: Danish Forest and Nature Agency

Maintenance: Irregular (last update: February 2009)

Contact: sns@sns.dk

Weblink: http://www.skovognatur.dk/DyrOgPlanter/invasivearter/Arter/Sortlisten/

Coverage

- Geographical coverage: Denmark
- EU Member States: 1
- Alien taxa: 54
- Organism groups/environments: all
- Resolution: country

Data sources

- Unspecified

Accessibility

- List of species names, organized per organism group
- No data export module
- In Danish

Species information

- Impact: no information
- Establishment: no information
- Measures: no information on nature of measures, but see note for ‘manageability’
- Year of introduction: not available
- Pathway of introduction: no information
- Taxonomy: 13 organism groups
- Synonyms: no
- Common names: Danish
- Ecology (habitat): aquatic or terrestrial
- Referenced occurrences: no
- Coordinates: no

Notes

- The species are assigned a level of manageability:
    - hard to reduce to acceptable local levels or eradicate locally, or to eradicate locally
    - can be fought reduced or eradicated locally, but not at national level
    - can be eradicated locally and nationally

16. EL-MAR

Full name: Ellenic Network on Aquatic Invasive Species (ELNAIS) database

Management: Ellenic Network on Aquatic Invasive Species (ELNAIS)

Maintenance: Regular (last update October 2010)

Contact: content: Argyro Zenetos (zenetos@ath.hcmr.gr), technical support: Balopoulou Stavroula (smpalop@ath.hcmr.gr)

Weblink: https://services.ath.hcmr.gr/index.php?option=com_content&task=view&id=22&Itemid=39

Coverage

- Geographical coverage:Greece
- EU Member States: 1
- Alien taxa: 285 (275 at moment of data extraction)
- Organism groups/environments: marine/brackish waters
- Resolution: point data or distribution areas in maps

Data sources

- Literature + alien species databases

Accessibility

- Table with alphabetically ordered species list and hyperlinked distribution maps
- No data export module
- In English

Species information

- Impact: no information
- Establishment: categorized (established, questionable, casual, cryptogenic or unknown)
- Measures: no information
- Year of introduction: available for all species
- Pathway of introduction: no information
- Taxonomy: major organism and ecofunctional groups
- Synonyms: no
- Common names: no
- Ecology (habitat): categorized (marine, freshwater, estuarine)
- Referenced occurrences: no, but species specific publication or reference database
- Coordinates: not provided, but species specific point or distribution maps

Notes

- none

17. EE

Full name: Estonian Alien Species Database

Management: Ministry of Environment

Maintenance: unknown

Contact: Lilika Käis (lilika.kais@envir.ee)

Weblink: http://loodus.keskkonnainfo.ee/voorliigid/ (old link deactivated: http://eelis.ic.envir.ee/voorliigid/eng/?a=nimekiri)

Coverage

- Geographical coverage: Estonia
- EU Member States: 1
- Alien taxa: 920
- Organism groups/environments: all
- Resolution: country

Data sources

- Literature

Accessibility

- Search engine (keyword x organism group x area of origin) + species list with filters
- No data export module
- In Estonian (English version not accessible)

Species information

- Impact: Basic information on economic impacts and ecological effects
- Establishment: categorized (rare, occasional, distributed, common) + description in species fact sheet
- Measures: no information
- Year of introduction: for some species
- Pathway of introduction: description in species fact sheet
- Taxonomy: major organism groups + class
- Synonyms: no
- Common names: Estonian for few species
- Ecology (habitat): no information
- Referenced occurrences: no, but species specific reference list
- Coordinates: no

Notes

- Includes also the species-specific region of origin

18. ES

Full name: Invasive Exotic Species of the Iberian Peninsula (InvasIber; 'Especies Exoticas Invasores de la Peninsula Iberica')

Management: Department of Environmental Sciences, University of Girona, Spain

Maintenance: Irregular (some species fact sheets have not been updated for more than 5 years)

Contact: Emili García-Berthou (emili.garcia@udg.edu)

Weblink: http://invasiber.org/fitxa_llista.php?taxonomic=2

Coverage

- Geographical coverage: Spain
- EU Member States: 1
- Alien taxa: 49
- Organism groups/environments: all
- Resolution: country

Data sources

- Literature

Accessibility

- Species search engine (not functional) + tabbed list of species, organized per organism group
- No data export module
- In Spanish

Species information

- Impact: ecological and socioeconomic impact described in species fact sheet
- Establishment: description of establishment in Spain in species fact sheet
- Measures: no information
- Year of introduction: no
- Pathway of introduction: description in species fact sheet
- Taxonomy: Family - Order
- Synonyms: no
- Common names: English, if available also Spanish, Catalan, Euskara and Galician)
- Ecology (habitat): description in species fact sheet
- Referenced occurrences: no (but species specific reference list)
- Coordinates: no

Notes

- No

19. IE

Full name: National Invasive Species Database (Ireland)

Management: National Biodiversity Data Centre

Maintenance: Regular (notification of recent updates on site)

Contact: Colette O' Flynn (coflynn@biodiversityireland.ie)

Weblink: http://apps.biodiversityireland.ie/SpeciesBrowser/

Coverage

- Geographical coverage: Republic of Ireland (IE) + Northern Ireland (UK)
- EU Member States: 1 (2)
- Alien taxa: 93 species (21254 records)
- Organism groups/environments: all
- Resolution: 10x10 km (0.1x0.1 km for some species)

Data sources

- Literature
- Voluntary contributions (online submission module with review)
- Experts

Accessibility

- Species search engine and hyperlinked species list (alphabetically ordered)
- No export module for selection of records, but downloadable distribution maps for 90 species
- In English

Species information

- Impact: categorized
- Establishment: count per 10 km square
- Measures: no information
- Year of introduction: available (year of first reporting)
- Pathway of introduction: categorized
- Taxonomy: major organism groups
- Synonyms: yes
- Common names: English, Gaelic
- Ecology (habitat): brief description can be provided in a comments section of the species fact sheet
- Referenced occurrences: occurrences are linked at species level to publications (full reference list can be exported as PDF file)
- Coordinates: yes (aggregated into grids of 0.01 or 100 km^2)

Notes

- Includes also potential invaders (not extracted for this study)
- Possibility to submit records online
- Interactive GIS-based mapping interface (10x10 km grid with multiple GIS layers)
- For each occurrence record information on the date, recorder, site, and notes.

20. IE-PLANTS

Full name: Database of Alien Plants in Ireland

Management: School of Natural Sciences, Botany Department, Trinity College Dublin

Maintenance: Irregular (last update in May 2008)

Contact: Ann Milbau (ann.milbau@ua.ac.be) & Jane C. Stout (stoutj@tcd.ie)

Weblink: http://www.biochange.ie/alienplants/search.php

Coverage

- Geographical coverage: Republic of Ireland (IE) + Northern Ireland (UK)
- EU Member States: 1 (2)
- Alien taxa: 433 (casual and naturalized aliens)
- Organism groups/environments: plants
- Resolution: vice county

Data sources

- Largely based on 'A Catalogue Of Alien Plants in Ireland' (Reynolds, 2002), supplemented with voluntary additions

Accessibility

- Species search engine (multilingual) + categorized search (vice-county x invasive status x family)
- No data export module
- In English

Species information

- Impact: no specific information (mostly weeds)
- Establishment: number of 10x10 km cells + abundance category at country level
- Measures: no specific information
- Year of introduction: available, if known
- Pathway of introduction: available, if known
- Taxonomy: Family
- Synonyms: yes
- Common names: English, French, Dutch, German
- Ecology (habitat): detailed species factsheets
- Referenced occurrences: yes
- Coordinates: no (occurrences are lumped in 10x10 km cells and vice-counties)

Notes

- The database includes also naturalized species (not extracted for report, only casual and invasive aliens were considered)

21. LT

Full name: Lithuanian Invasive Species Database

Management: Klaipeda University, Coastal Research and Planning Institute

Maintenance: Irregular (last reference is from 2001)

Contact: Sergej Olenin (serg@gmf.ku.lt)

Weblink: http://www.ku.lt/lisd/species.html

Coverage

- Geographical coverage: Lithuania
- EU Member States: 1
- Alien taxa: 669
- Organism groups/environments: all
- Resolution: country

Data sources

- Literature

Accessibility

- Alphabetic list of species + categorized search (terrestrial, inland water, coastal water)
- No data export module
- In English

Species information

- Impact: no information
- Establishment: no information
- Measures: no information
- Year of introduction: year of first record available
- Pathway of introduction: no
- Taxonomy: major organism groups
- Synonyms: no
- Common names: no
- Ecology (habitat): coastal waters, inland waters, terrestrial
- Referenced occurrences: yes, to publication
- Coordinates: no

Notes

- includes species specific region of origin

22. LU-PLANTS

Full name: Neophyten in Luxemburg

Management: National Museum of Natural History (Ecology Section)

Maintenance: Regular (list of project-based activities organised per year)

Contact: Christian Ries (cries@mnhn.lu) and Manuel Kunsch (mkunsch@mnhn.lu)

Weblink: http://www.mnhnl.lu/cgi-bin/baseportal.pl?htx=/projects/neophytes/neophytes

Coverage

- Geographical coverage: Luxemburg
- EU Member States: 1
- Alien taxa: 22
- Organism groups/environments: plants
- Resolution: country

Data sources

- Literature, research projects, experts

Accessibility

- Alphabetic hyperlinked list of species, categorized according to potential impact
- No data export module
- Multilingual

Species information

- Impact: Categorized (problematic, potentially problematic and little or not problematic)
- Establishment: Categorized (established, not established)
- Measures: Best practice manuals for selection of species
- Year of introduction: no
- Pathway of introduction: not systematically (can be described in species fact sheet)
- Taxonomy: no
- Synonyms: no
- Common names: German, French, English, Dutch
- Ecology (habitat): description in species fact sheet
- Referenced occurrences: yes (publication or project)
- Coordinates: no

Notes

- Linked to Wikispecies and Wikipedia

23. NO

Full name: Norwegian Alien Species Database

Management: Norwegian Biodiversity Information Centre

Maintenance: Irregular (last update species factsheets in May 2007)

Contact: postmottak@artsdatabanken.no

Weblink: http://www.artsdatabanken.no/Article.aspx?m=173&amid=2578

Coverage

- Geographical coverage: Norway
- EU Member States: 1
- Alien taxa: 203
- Organism groups/environments: all
- Resolution: country

Data sources

- Unspecified (references to papers in species fact sheets)

Accessibility

- Species search engine + categorized search (organism group x risk x pathway x environment x vector x decade of first observation x origin)
- No data export module
- In Norwegian

Species information

- Impact: Categorized (high, low, unknown risk)
- Establishment: rough estimate of number of individuals at country level
- Measures: no information
- Year of introduction: categorized (decade)
- Pathway of introduction: categorized
- Taxonomy: 22 organism groups
- Synonyms: no
- Common names: Norwegian
- Ecology (habitat): habitat categorization + description in species fact sheets
- Referenced occurrences: no, but species specific references
- Coordinates: no

Notes

- Biodiversity database (2485 species) with identification of alien species

24. PO

Full name: Alien Species in Poland

Management: Institute of Nature Conservation PAS, Polish Academy of Sciences

Maintenance: Regular (several updates per month)

Contact: ias@iop.krakow.pl

Weblink: http://www.iop.krakow.pl/ias/Baza.aspx

Coverage

- Geographical coverage: Poland
- EU Member States: 1
- Alien taxa: 1151 (1007 at moment of data extraction)
- Organism groups/environments: all
- Resolution: 'physiographic units' of ca. 100-1000 km^2

Data sources

- Experts, network of collaborators, literature

Accessibility

- Species search + categorized search (organism group or status)
- No data export module
- English and Polish

Species information

- Impact: no information
- Establishment: categorized + distribution maps in Poland
- Measures: control or eradication measures are not specified, but the success of measures is categorized (e.g. controlled with limited, successfully eradicated, etc.)
- Year of introduction: point of earliest introduction indicated in map, extensive literature list per species
- Pathway of introduction: specified
- Taxonomy: Phylum – Class – Order - Phylum
- Synonyms: yes
- Common names: English and Polish
- Ecology (habitat): details in species fact sheets for most species
- Referenced occurrences: no, but extensive reference list at species level
- Coordinates: no (occurrences are lumped into 'physiographic units' of ca. 100-1000 m^2)

Notes

- Integrated in NOBANIS and DAISIE
- Database structure follows GISIN guidelines

25. PT-PLANTS

Full name: Invasive Plants Species in Portugal

Management:

- Centre for Functional Ecology of the University of Coimbra
- Center for Studies of Natural Resources, Environment and Society, Agrarian School of Coimbra

Maintenance: Irregular (Last update on website: March 2010; species fact sheets were made in December 2005, and have not been updated)

Contact: invader@ci.uc.pt

Weblink: http://www1.ci.uc.pt/invasoras/index.php?menu=114&language=eng&tabela=especies

Coverage

- Geographical coverage: Portugal
- EU Member States: 1
- Alien taxa: 32
- Organism groups/environments: plants
- Resolution: regional (12 regions in Portugal)

Data sources

- Expert contributions, literature

Accessibility

- Hyperlinked alphabetic species list
- No data export module
- Mainly Portuguese (Species factsheets only in Portuguese, interface partly in English)

Species information

- Impact: no systematic assessment; impacts may be described in species fact sheets
- Establishment: only invasive species are listed (distribution maps in species fact sheets)
- Measures: description in species fact sheets
- Year of introduction: no
- Pathway of introduction: no systematic assessment; impacts may be described in species fact sheets
- Taxonomy: Family and phylum
- Synonyms: in species fact sheet
- Common names: Portuguese (in species fact sheet)
- Ecology (habitat): Description in species fact sheet
- Referenced occurrences: No, but author of species fact sheets is specified + extensive species specific bibliography
- Coordinates: not available

Notes

- Invasive plants species database (contains also naturalized species which were not extracted for this report)
- Tool for mapping distributions is under development
- Contains practical identification guides for plant species

26. SE-MAR

Full name: Alien species in Swedish seas and coastal areas

Management: Three regional information offices (Skagerrak/Kattegat area, Baltic Sea proper, Gulf of Bothnia)

Maintenance:

- Last update of website: November 2010
- Website is project-based (project end: January 2008)
- Most species factsheet were created and last updated in 2005-2006

Contact: informationscentral.stockholm@lansstyrelsen.se, vasterbotten@lansstyrelsen.se, vattenvard.vastragotaland@lansstyrelsen.se

Weblink: http://www.frammandearter.se/

Coverage

- Geographical coverage: Swedish seas and coastal areas
- EU Member States: 1
- Alien taxa: 72
- Organism groups/environments: marine/brackish waters
- Resolution: country (more detailed description in species fact sheet for some species)

Data sources

- Experts, literature

Accessibility

- Partly hyperlinked list of species organised per organism group
- Species list can be downloaded as PDF file
- Swedish and English

Species information

- Impact: description of ecological and other effects in species fact sheet for some species
- Establishment: description of occurrence in Swedish and adjacent seas for some species
- Measures: no information
- Year of introduction: for some species
- Pathway of introduction: description of probable means of introduction in species fact sheet for some species
- Taxonomy: 25 organism groups
- Synonyms: no
- Common names: subset in English, Danish, Norwegian, Swedish
- Ecology (habitat): description in species fact sheet for some species
- Referenced occurrences: no (list of references in species fact sheets)
- Coordinates: no

Notes

- Contains also an alert list of alien species observed close to the Swedish border
- In species fact sheets extensive reference list of projects, reports and institutes

27. UK

Full name: Non-Native Species Information Portal (NNSIP)

Management: GB Non-native Species Secretariat

Maintenance: Unknown (under construction)

Contact: nnss@fera.gsi.gov.uk

Weblink: https://secure.fera.defra.gov.uk/nonnativespecies/home/index.cfm (old deactivated link: http://138.253.199.114/IAAP%20Web/IAAPwebsite/IASspecies.asp)

Coverage

- Geographical coverage: United Kingdom
- EU Member States: 1
- Alien taxa: 20*, 3000*, 147*
- Organism groups/environments: all
- Resolution: site

Data sources

- Voluntary contributions + unknown

Accessibility

- Species search engine (under construction) + alphabetical hyperlinked species list
- No data export module, species fact sheets downloadable as PDF
- In English

Species information

- Impact: description of ecosystems impact, health and social impact and social impact in species fact sheets
- Establishment: map of UK with point data + description of current status in species fact sheets
- Measures: description of categorized management options
- Year of introduction: available
- Pathway of introduction: description in species fact sheet
- Taxonomy: full taxonomy
- Synonyms: no
- Common names: English
- Ecology (habitat): description in species fact sheet
- Referenced occurrences: no, authors of species fact sheets are identifiable
- Coordinates: no, but point data maps

Notes

- The data portal is under construction. Currently detailed information is available for only 20 species, but distribution data and basic information should become available for ca. 3000 species. The database description is based on the information available for the 20 species. The data collected for this report were extracted from a website that has now been deactivated (147 species)

28. UK(E)

Full name: Audit of Non-Native Species in England

Management: Natural England

Maintenance: no maintenance (published: Hill et al., 2005)

Contact: enquiries@naturalengland.org.uk

Weblink: http://www.brc.ac.uk/resources.htm

Coverage

- Geographical coverage: England (United Kingdom)
- EU Member States: (1)
- Alien taxa: 2644
- Organism groups/environments: all
- Resolution: district (n=9)

Data sources

- 15 contributors (1 private + 3 institutions: Biological Records Centre of the Centre for Ecology and Hydrology + Department for Environment Food and Rural Affairs: Centre for Environment, Fisheries and Aquaculture Science + Central Science Laboratory)

Accessibility

- Downloadable Excel file
- In English

Species information

- Impact: categorized economic and environmental impact
- Establishment: categorized for England + presence/absence per district
- Measures: categorized (no control, chemical, biological, environmental or direct)
- Year of introduction: For most species dates of introduction and first record in the wild
- Pathway of introduction: categorized
- Taxonomy: 51 organism groups
- Synonyms: no
- Common names: English
- Ecology (habitat): Categorized (EUNIS codes)
- Referenced occurrences: no, but with identification of contributor at species level
- Coordinates: not available

Notes

- The file contains additional species specific information such as the nature value in England and expected population trend in next 20 years
- The database includes also species that were formerly native, that are native but experienced a large addition from domestic or non-native stock, and species that may be native or alien, but are probably alien. The categories were not considered for the report (See Materials and Methods section for description of included categories).

29. UK(N)

Full name: Invasive Alien Species in Northern Ireland

Management: Biodiversity Unit, Northern Ireland Environment Agency

Maintenance: Irregular

Contact: CEDaR.info@nmni.com

Weblink: http://www.habitas.org.uk/invasive/splist.asp?Sort=NI&Type=

Coverage

- Geographical coverage: Northern Ireland
- EU Member States: (1)
- Alien taxa: 49
- Organism groups/environments: all
- Resolution: 10x10 km

Data sources

- Experts, literature

Accessibility

- Hyperlinked species list, organised per organism group
- No data export module
- In English

Species information

- Impact: wildlife and management impacts and human impacts described in species fact sheet
- Establishment: map with occurrences (10x10 km) + description in species fact sheet
- Measures: description in species fact sheet
- Year of introduction: for some species mentioned in text of species fact sheet + occurrences are categorized in three periods (pre 1970, 1970-1986, post 1986)
- Pathway of introduction: often described in species fact sheet
- Taxonomy: 7 organism groups
- Synonyms: no
- Common names: English
- Ecology (habitat): description in species fact sheet
- Referenced occurrences: no, but authors of species fact sheets are acknowledged
- Coordinates: not available (map of occurrences at 10x10 km resolution)

Notes

- The site also contains a list of species that are not yet present in Northern Ireland

30. UK-MAR

Full name: Non-native marine species in British waters: a review and directory

Management: Joint Nature Conservation Committee

Maintenance: no maintenance (book published in 1997)

Contact: comment@jncc.gov.uk

Weblink: http://www.jncc.gov.uk/page-2597

Coverage

- Geographical coverage: British waters
- EU Member States: (1) (England, Scotland and Wales)
- Alien taxa: 69
- Organism groups/environments: marine waters
- Resolution: subnational region

Data sources

- Experts (through questionnaire) + literature + research projects

Accessibility

- PDF of book (contains 2 tables with species lists, organized per organism group)
- In English

Species information

- Impact: Species specific description of effects on environment and commercial interests
- Establishment: species specific description
- Measures: species specific description (no information for many species)
- Year of introduction: available for most species
- Pathway of introduction: available if known
- Taxonomy: Phylum – Class - Order
- Synonyms: no
- Common names: English
- Ecology (habitat): marine species
- Referenced occurrences: no, but identification of species fact sheet compiler and extensive reference list in species fact sheet
- Coordinates: no

Notes

- Only available in PDF format (Book: Eno N.C., Clark R.A. & Sanderson W.G., 1997, Non-native marine species in British waters: a review and directory. Published by the Joint Nature Conservation Committee, ISBN1861074425, pp. 152.)

Annex 2: Definitions

DAISIE: alien species (synonyms: exotic, introduced or non-native species)

Species, subspecies, or lower taxon occurring outside of the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans.

NOBANIS: alien species (synonyms: non-native, non-indigenous, foreign, exotic, introduced species)

Species, subspecies or lower taxon (such as a variety, race, provenance or stock), introduced outside its natural past or present distribution; including any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (COP 6, decision VI/23[3]).

CIESM: alien species

The CIESM atlases consider as alien those species that are 'exotic' to Mediterranean Sea and that have not been recorded more than once or twice, depending on the organism group. Exotic species are then defined as species that have not appeared in the Mediterranean Sea (a) before the 1920s for Lessepsian species, (decade when the Cambridge expedition took place and provided a reliable baseline); or (b) before the 1960s for the others (before 1950s for the crustaceans). More frequently recorded exotic species are defined as established exotic species.

BE: alien species (synonyms: exotic or non native species)

An organism whose presence in a given area is due to intentional or accidental introduction by man (= introduction by man outside its natural range and dispersal potential). Note that natural extension of geographic range induced by global warming is not considered here.
An alien species can be considered as acclimatised if it is able to survive for a long period of time in its new environment. It is considered as naturalised as soon as it is able to reproduce consistently in the wild and sustain populations over several life-cycles without direct intervention by man (= self-perpetuating populations).
Finally, an alien species is considered as invasive when it is naturalised and able to increase population size, to disperse widely in the environment and to colonise semi-natural habitats.
This definition doesn't take potential impact on native biodiversity into account; some invasive species can be considered as 'benign invaders' because no adverse impact on biodiversity is known.

BE-MAR: alien species

A species that was - intentionally or not - introduced by man. If there is a presumption that a cryptogenic species was introduced, this species was also added to the list. Excluded: alien species without permanently established populations, and species that arrived in the Belgian coastal waters by natural distribution.

DE-AQ: alien species

Species that were directly or indirectly introduced by man after 1492 and that are known to live permanent in German waters. The few species identified recently as introduced before 1492, also denoted as archaeobiota - archaeophytes / archaeomycetes / archaeozoans (e.g., soft clam *Mya areanaria*, common carp *Cyprinus caprio*) were thus excluded from the list of aliens.

EL-MAR: invasive alien species (IAS)

Non-native species that are introduced deliberately or unintentionally outside their natural habitats where they become established, proliferate and spread in ways that cause damage to biodiversity, human heath, loss of production etc. EL-MAR includes not only IAS but casual records as well.

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[3] COP 6, decision VI/23 - on alien species that threaten ecosystems, habitats or species.

ES: Invasive exotic species

Introduced and established/naturalized species. In principle non-established alien species are excluded (i.e. casual aliens and species kept in captivity).

LT: Introduced species (synonyms: non-indigenous, non-native, alien, exotic species)

Intentionally or accidentally transported and released by man outside their native range. An invasive species is defined as "an introduced species which becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biological diversity" (IUCN 1999).

LU-PLANTS: Neophytes

Plants that are introduced consciously or unconsciously, directly or indirectly by humans since 1492 into areas where they do not occur naturally. Plants that were introduced before the discovery of America are called archaeophytes. All alien species regardless of time of introduction are known as alien species. Alien plants are often introduced intentionally …
About half the neophytes were introduced, unintentionally …
Most neophytes can reproduce …. If they occur only sporadically in the wild, they are referred to as "unstable neophytes" or adventitious. If they form stable populations and reproduce for several generations without direct assistance of the people, they are referred to as "established neophytes". Non-resident plant species (i.e. archaeophytes and neophytes), which persist in natural ecosystems such as forests or meadows even in the absence of human impact, are termed agriophytes.

NO: Invasive species

Species that spread by human activities to areas where they do not belong naturally. Some of them are a threat to biological diversity.

PO: Alien species

A species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (COP 6, decision VI/23; "European Strategy on Invasive Alien Species" adopted by the Standing Committee of the Bern Convention).
Invasive alien species (IAS): an alien species whose introduction and/or spread threaten biological diversity. (For pragmatic reasons, in the database this group also includes alien species whose introduction and/or spread threaten economy and/or human health).
Introduction: the movement by human agency, indirect or direct, of an alien species outside of its natural range (past or present). This movement can be either within a country or between countries or areas beyond national jurisdiction.

SE-MAR: Alien species (synonyms: non-indigenous, non-native, exotic species)

A plant, animal or microorganism which, with the help of humans, has been transported from and spread outside its natural distribution range. Introduction may be deliberate or accidental. Some of these new species — the invasive ones — cause problems in our seas, lakes and watercourses, as well as on land. Other introduced species do not seem to do any harm.

UK: non-native species

Land animals and plants that have become established since man first arrived (Britain: about 8,000 years ago) and have been brought by man.
Invasive non-native species: Non-native species that have serious negative impacts on the our native species, our health or our economy.

UK(E): non-native species

- A species introduced (i.e. by human action) outside its natural past or present distribution. Included: pests of agriculture. Garden pests such as the lily beetle *Lilioceris lilii* are included in the database but reported separately. Many naturalized species and some natives are confined to man-made habitats such as farmland, or the vicinity of buildings. Rather than define what is meant by 'in the wild', it is explicitly stated that species should occur outside buildings, captivity or cultivation.
  Excluded: Native species that are introduced by human activity (e.g. farmers sow a vast acreage of perennial ryegrass *Lolium perenne*; foresters plant large areas of pedunculate oak *Quercus robur*; gardeners plant yew *Taxus baccata* for hedging; anglers stock brown trout *Salmo trutta*; and sporting estates augment the population of grey partridge *Perdix perdix*.
  This is further refined according to the organism group the species belongs:
    - Birds: The British Ornithologists' Union definitions refer to introduced species as 'naturalised'.
    - Plants: For plant species, which may be very long-lived, it is customary to have a category 'persisting', i.e. released into the countryside, persisting for five or more years, but not effectively reproducing. Many such species, especially forest trees, are included in the standard floras, and they have been retained for the purposes of the audit of aliens. Effectively, a species is deemed to be naturalized if it occurs as a self-sustaining population, persisting for more than four years, not dependent on repeated reintroduction. Some plants, including natives, can sustain themselves as clones that do not reproduce except vegetatively.
    - Animals: Self-sustaining animal populations are those that breed.

  Several types of non-nativeness are identified:
    - Introduced species: not present as native in post-glacial period; this includes taxa that have spread naturally to Britain from introduced populations in Europe, eg Harlequin ladybird *Harmonia axyridis*).
    - Reintroduced species / formerly native (extinct as a native but present as introduced populations, commonly called re-introductions; these may be deliberate or accidental and may be genetically distinct from the original population).
    - Newly arrived species: taxa with an unknown history that appear to have arrived since 1950 and from their subsequent behaviour seem likely to be introductions. These are typically less well known taxa, for which there is doubt as to whether a species that has newly arrived is native or alien.
    - Hybrid species / spontaneous hybrid between native and introduced taxa.
    - Native species with large addition from domestic or non-native stock.
    - Native or alien species: probably or possibly introduced.
    - New species derived from a spontaneous hybrid (e.g. as an allopolyploid).

UK(N): Invasive alien species

Species that have been introduced, either deliberately or unintentionally, to areas that are typically outside of their natural range or habitat. Over the last century increasing travel and trade have allowed many species to overcome the geographical barriers that previously restricted them. A number of these are highly invasive, establishing themselves in new terrestrial and aquatic environments.

UK-MAR: Non-native species

A species that has been introduced directly or indirectly by human agency (deliberately or otherwise) to an area where it has not occurred in historical times and which is separate from and lies outside the area where natural range extension could be expected. The species has become established in the wild and has self-maintaining populations. The term also includes hybrid taxa derived from such introductions.

European Commission

EUR 24752 EN – Joint Research Centre – Institute for Environment and Sustainability
Title: Alien species databases in Europe: Complementarity, coverage and compatibility
Authors: Jochen Vandekerkhove and Ana Cristina Cardoso
Luxembourg: Office for Official Publications of the European Communities
2011 – 65 pp. – 21 x 29.7 cm
EUR – Scientific and Technical Research series – ISSN 1831-9424
ISBN 978-92-79-19665-2
doi:10.2788/65974

Abstract
This report assesses the coverage of thirty existing on-line national, regional and global databases from which alien species occurrence records within the territory of the European Union can be retrieved. In addition, it quantifies their degree of complementarity, and as such the added value of an integrated information system. Finally, it includes a qualitative evaluation of the feasibility of combining alien species information from existing databases at EU level.
Our comparative analysis of occurrence data across 30 online databases with alien species records uncovers a high degree of complementarity of information. The most comprehensive resource for country level alien species occurrences in Europe (DAISIE) fails to report about one out of every four species known to be alien to one or more countries within the EU27 + Norway territory. When accessing only a single database, a minimum of 10,000 species by country records stay unaccounted for at European level.
The distributed and largely independent nature of existing alien species information systems has multiple consequences: (i) In the absence of an overarching data exploration system, it complicates the retrieval of information, and the identification of knowledge gaps; (ii) It allows systems to diverge and as such become less compatible; (iii) It potentially makes inefficient use of existing financial and intellectual resources.
The efficiency and accuracy of existing databases could be improved if communication between systems was enhanced. Expert knowledge could be shared and harmonization of the information would facilitate the retrieval of information, for example through a common network of interoperable web services. Integrated alien species databases currently report occurrences at country level, with limited value for scientists and managers. A shift towards georeferenced occurrences could be achieved in a cost-effective way by link linking to biodiversity databases and digitized archives of relevant journals.

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